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PART I

Bioventing Pilot Test Work Plan for Former Fire Training Area (FT-13) Kirtland AFB, New Mexico

PART II

Draft Interim Pilot Test Results Report for Former Fire Training Area (FT-13) Kirtland AFB, New Mexico

Prepared For

Air Force Center for Environmental Excellence
Brooks AFB, Texas

and

377th ABW/EM
Kirtland AFB, New Mexico

ENGINEERING-SCIENCE

ES
Engineering-Science, Inc.

1700 BROADWAY, SUITE 900
DENVER, COLORADO 80290

June 1993

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PART I

BIOVENTING PILOT TEST WORK PLAN

FOR

FORMER FIRE TRAINING AREA (FT-13)

KIRTLAND AFB, NEW MEXICO

June 1993

Prepared for:

Air Force Center for Environmental Excellence
Brooks AFB, Texas

and

377th ABW/EM
Kirtland AFB, New Mexico

by:

Engineering-Science, Inc.
1700 Broadway, Suite 900
Denver, Colorado

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BIOVENTING PILOT TEST WORK PLAN FOR FORMER FIRE TRAINING AREA (FT-13) KIRTLAND AFB, NEW MEXICO

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PART I

BIOVENTING TEST WORK PLAN FOR FORMER FIRE TRAINING AREA (FT-13) KIRTLAND AFB, NEW MEXICO

1.0 INTRODUCTION

This work plan presents the scope of an *in situ* bioventing pilot test for treatment of fuel-contaminated soils at the former fire training area at Kirtland Air Force Base (AFB), New Mexico. The pilot test has three primary objectives: 1) to assess the potential for supplying oxygen throughout the contaminated soil interval, 2) to determine the rate at which indigenous microorganisms will degrade fuel when stimulated by oxygen-rich soil gas, and 3) to evaluate the potential for sustaining these rates of biodegradation until fuel contamination is remediated to concentrations below regulatory standards.

The pilot test will be conducted in two phases. A vent well (VW) and monitoring points (MPs) will be installed during site investigation activities. The initial stage will also include an *in situ* respiration test and an air permeability test. This initial testing is expected to take approximately 2 weeks. During the second phase, a pilot bioventing system will be installed and monitored over a 1-year period.

If bioventing proves to be feasible at this site, pilot test data could be used to design a full-scale remediation system and to estimate the time required for site cleanup. An added benefit of the pilot testing at the fire training area is that a significant amount of the fuel contamination should be biodegraded during the 1-year pilot test, as the testing will take place within the most contaminated soils at the site.

Additional background information on the development and recent success of the bioventing technology is found in the *Test Plan and Technical Protocol For A Field Treatability Test For Bioventing* (Hinchee et al., 1992). This protocol document will also serve as the primary reference for pilot test well designs and detailed procedures which will be used during the test.

2.0 SITE DESCRIPTION

The majority of the material contained in this section is taken from site characterization reports by Engineering-Science, Inc. (ES) (1981), Science

Applications International Corporation (SAIC) (1985), U.S. Geological Survey (1992), and U.S. Geological Survey (1993).

2.1 Site Location and History

The former fire training area is a 0.7-acre site located near the western boundary of Kirtland AFB, about 600 feet southwest of the FAA control tower (Figure 2.1). The site consists of a 400-foot diameter circular graded area which contains a 65-foot diameter concrete pad surrounded by a 1.5-foot high earthen berm (Figure 2.2). The concrete pad was constructed in 1976 and contains an airplane mockup and a jet fuel sprinkler system. Because of fire training activities, the concrete pad is heavily degraded. In addition, a JP-4 fuel storage area and two unlined pits are located in the fire training area. The pits were used for fire training and disposal of solvents and oils generated by the base between 1952 and 1976. According to base personnel, solvents and oils were dumped at a rate of one to two 55 gallon drums per month during this period.

Fire training exercises during the late 1970's and 1980's generally consisted of spraying the mockup aircraft with jet fuel, igniting the fuel, and extinguishing the fire with aqueous film forming foam (AFFF). After a fire training exercise, residual liquids were allowed to infiltrate and evaporate. Prior to construction of the concrete-lined fire training area in 1976, fire training was conducted in the same area using unlined pits. A pit was soaked with water (to minimize fuel infiltration) and approximately 200 to 300 gallons of fuel was placed in the pit, ignited, and extinguished with AFFF foam. The residual fuel was allowed to infiltrate and evaporate. The last fire training exercise at this site was conducted in March 1990.

2.2 Site Geology

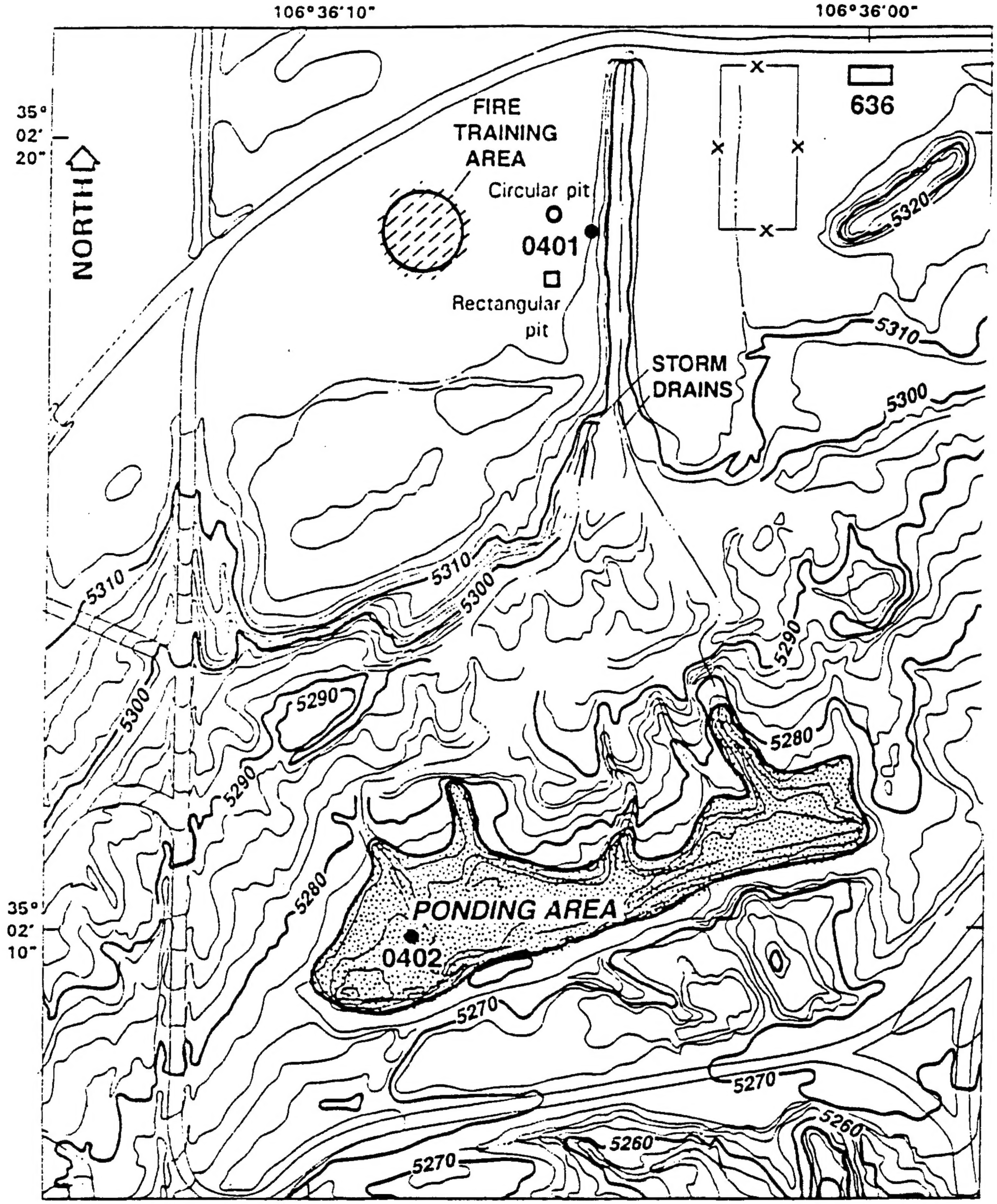
Shallow soils at the former fire training area are comprised of sand, sandy clay, and clay (Figure 2.3). The sands, silts, clays, and gravels of the Sante Fe Formation underlie the shallow soils at the fire training area. Ground water occurs in the Sante Fe Formation at a depth of about 430 feet below ground surface (bgs) and generally flows to the northeast.

2.3 Site Contaminants

The primary contaminants at this site are petroleum hydrocarbons, which have been detected in the soils at depths ranging from the surface to approximately 20 feet bgs (Figure 2.4). The greatest petroleum hydrocarbon concentrations occur immediately adjacent to the airplane mockup. Soil samples collected from soil boring FTA-10 by SAIC (1985) show oil and grease concentrations of 1300 mg/Kg at 5 feet bgs, 6500 mg/Kg at 15 feet bgs, and 1200 mg/Kg at 20 feet bgs. In addition, a soil gas survey conducted by the U.S.G.S. in 1991, shows maximum JP-4 concentrations near soil boring FTA-10 and extending to the west; being concentrated in the area beneath the concrete pad.

2.4 Manzano Fire Training Area FT-14

The Manzano fire training area is located within the Manzano Base compound north of the Manzano gate (Figure 2.5). The site consists of 2 burn pits located



Basemap:KAFB/CES,1976

0 200 400 FEET

CONTOUR INTERVAL 2 FEET

EXPLANATION

SOIL GAS SURVEY

● SOIL SAMPLING LOCATION AND LOCATION NUMBER--Power augered to 25 feet

Source: U.S.G.S., 1993.

FIGURE 2.1

VICINITY MAP
FORMER FIRE TRAINING AREA

KIRTLAND AFB, NEW MEXICO

ENGINEERING-SCIENCE, INC.
Denver, Colorado

ES

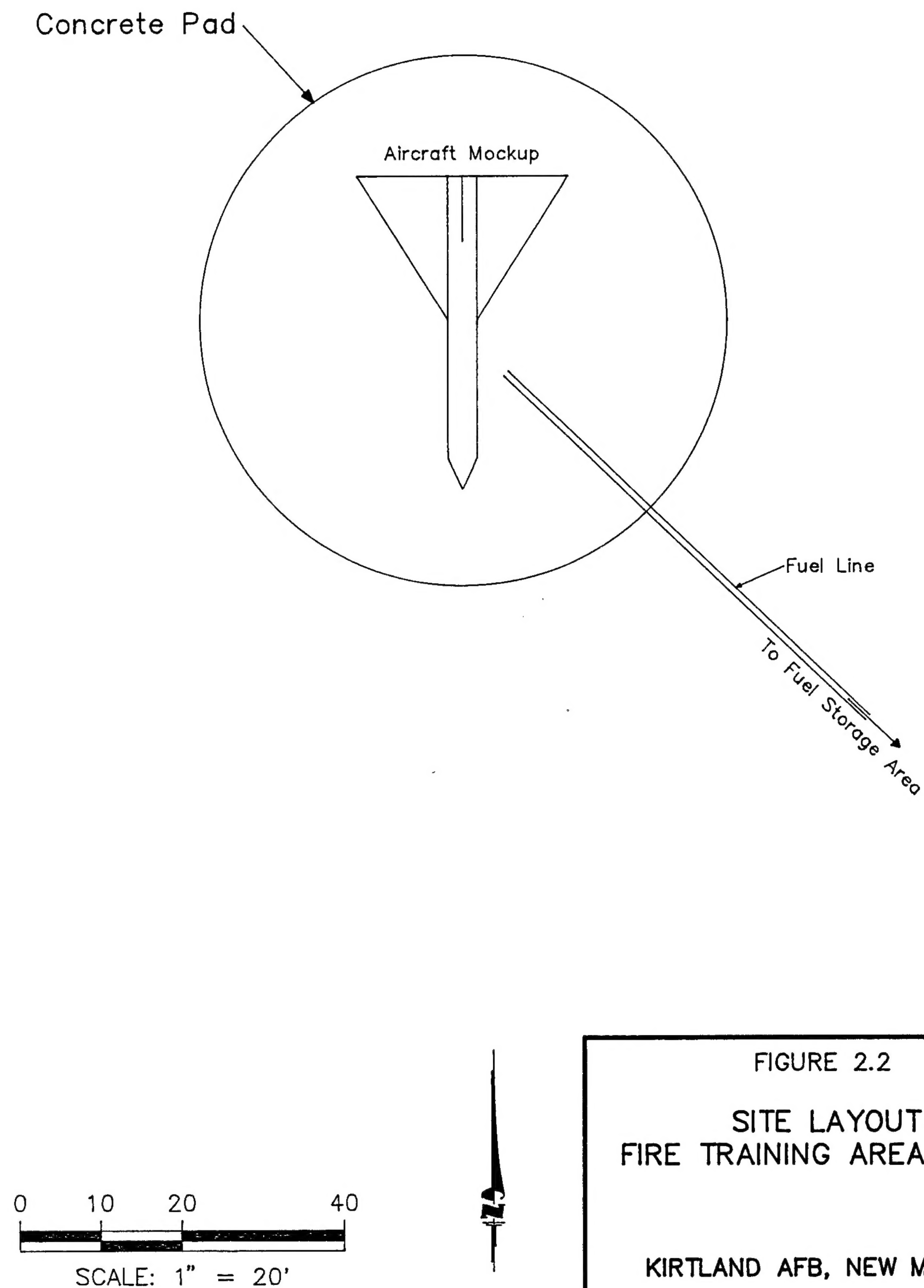


FIGURE 2.2

SITE LAYOUT
FIRE TRAINING AREA FT-13

KIRTLAND AFB, NEW MEXICO

ENGINEERING-SCIENCE, INC.
Denver, Colorado

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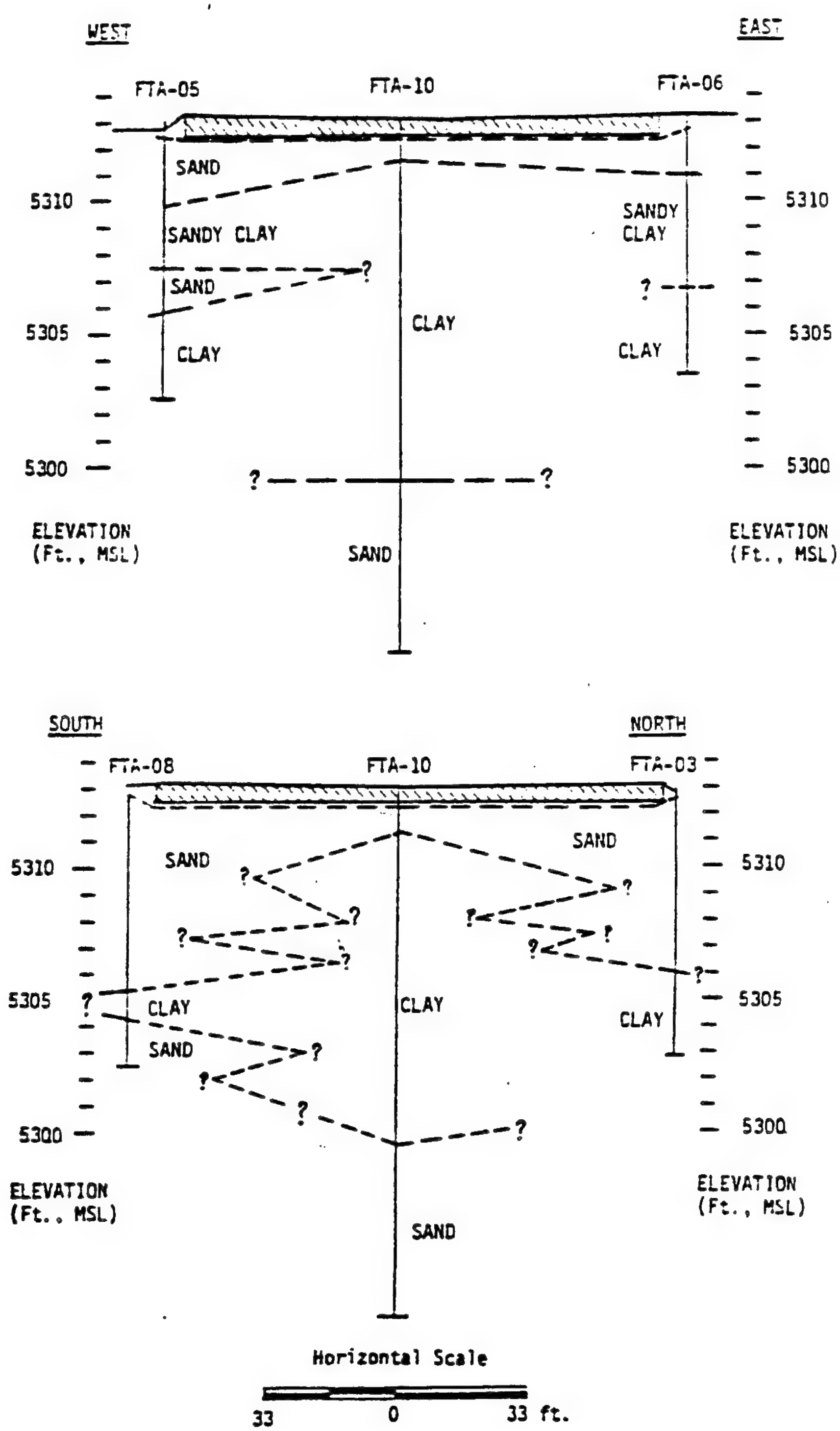


NOTE: LINE OF SECTION SHOWN ON FIGURE 2.4.

Source: SAIC, 1985.

FIGURE 2.3

GEOLOGIC CROSS SECTION FORMER FIRE TRAINING AREA

KIRTLAND AFB, NEW MEXICO

ENGINEERING-SCIENCE, INC.
Denver, Colorado

ES

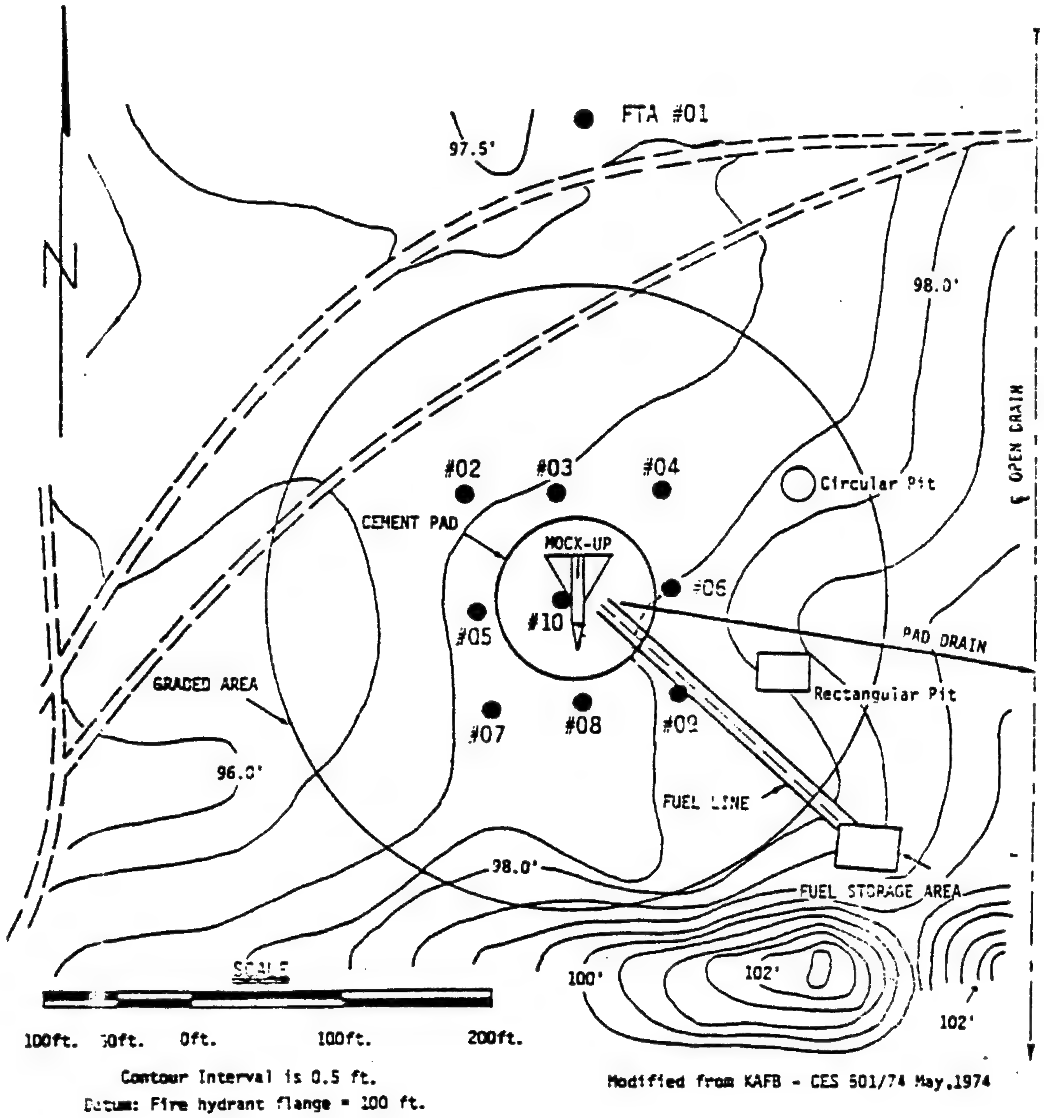


FIGURE 2.4

SAIC SOIL BORING LOCATIONS FORMER FIRE TRAINING AREA

KIRTLAND AFB, NEW MEXICO

ENGINEERING-SCIENCE, INC.
Denver, Colorado

Source: SAIC, 1985.

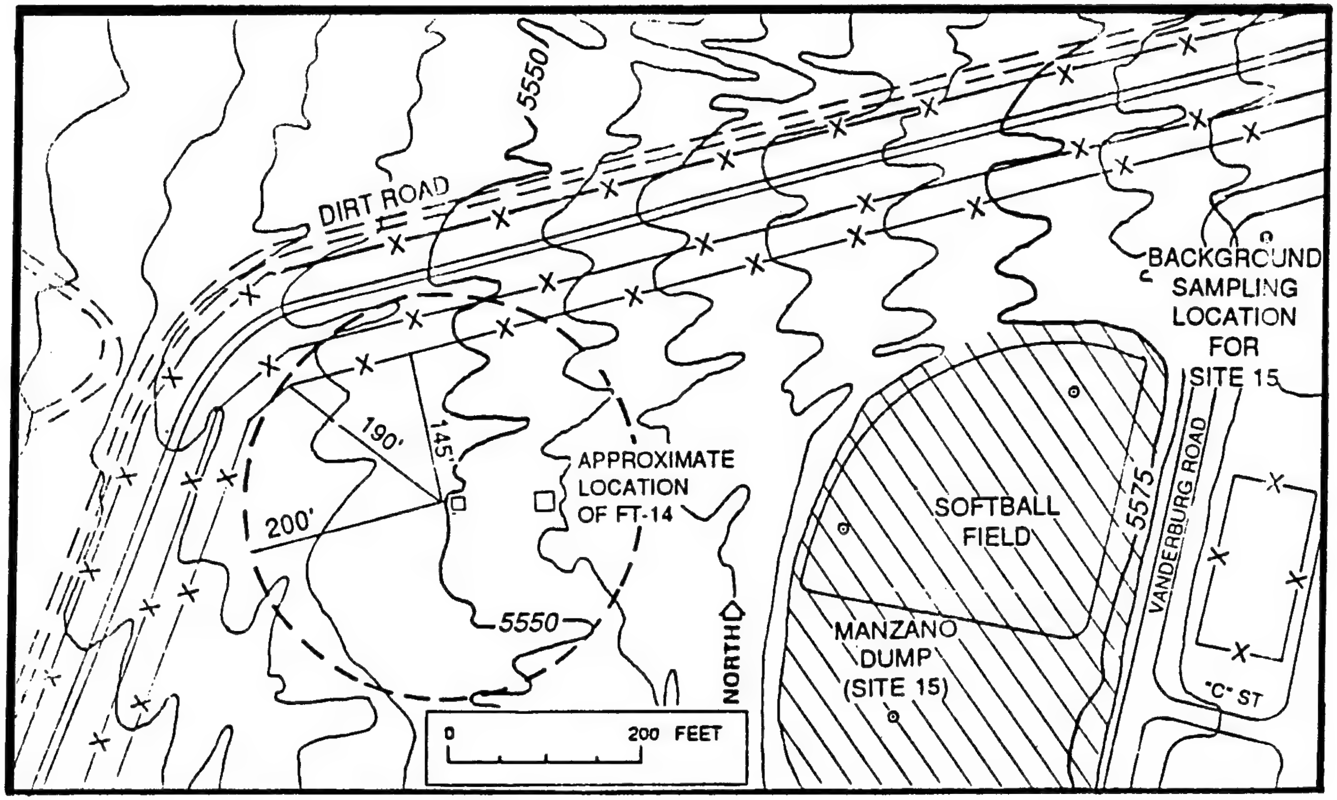


FIGURE 2.5

VICINITY MAP
MANZANO FIRE TRAINING AREA

KIRTLAND AFB, NEW MEXICO

ENGINEERING-SCIENCE, INC.
Denver, Colorado

ES

Source: U.S.G.S., 1993.

approximately 60 feet apart. Figure 2.6 shows the configuration of the burn pits. Both pits are 2 to 3 feet deep, with earthen berms that rise 1 to 2 feet above the surrounding land surface. Information on the procedures used, and the duration and frequency of fire training exercises conducted at this site is limited. Training procedures probably consisted of applying water to the fuel pit area, igniting the fuel, and extinguishing the fire with chemical foam. Because of the relative size of the facilities, the level of use is presumed to have been less than at fire training area FT-13.

Little geologic or contaminant information exists for this site. Surface staining indicates that wood burning and small quantities of oil and fuels were burned at this site. Because of the age of the contamination, and limited burning activities which occurred at this site, the potential for significant hydrocarbon contamination is considered low.

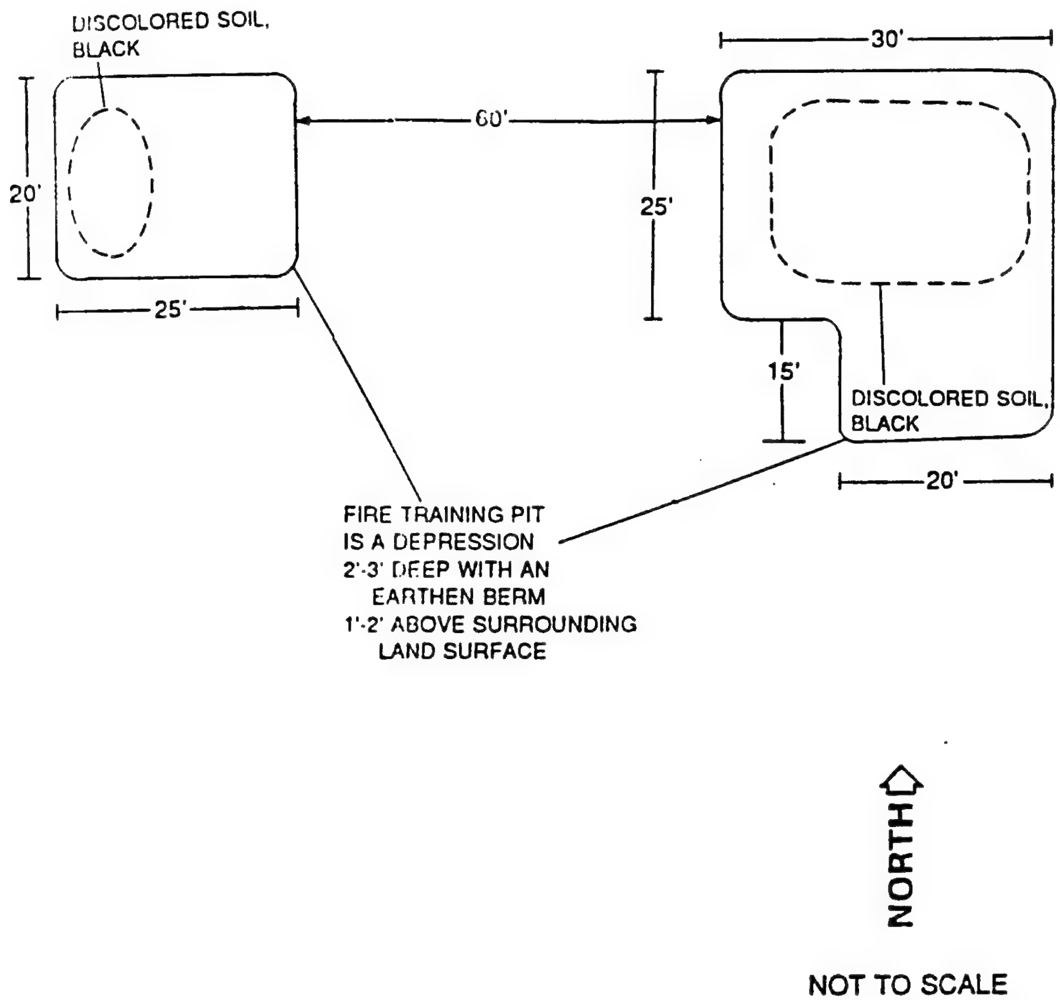
To screen this site for potential bioventing applications, ES will conduct a brief soil gas survey to determine if soil gas has been depleted of oxygen as a result of ongoing degradation of hydrocarbons. Two soil gas points will be hand driven near the center of each burn pit. Soil gas will be analyzed for total volatile hydrocarbons, oxygen, and carbon dioxide. If oxygen levels have been depleted to levels below two percent, the site will be instrumented for a bioventing pilot test using the general test layout and methods described in Section 3.

3.0 SITE SPECIFIC ACTIVITIES

The purpose of this section is to describe the work that will be performed by ES at the former fire training area. Activities to be performed include siting and construction of a central air injection well, or VW and four vapor MPs; an *in situ* respiration test; an air permeability test; and the installation of a long-term bioventing pilot test system. Soil and soil gas sampling procedures and the blower configuration that will be used to inject air (oxygen) into contaminated soils through the VW are also discussed in this section. No dewatering will take place during the pilot test. Pilot test activities will be confined to unsaturated soils remediation. Because of the great depth to the screened interval (approximately 400 feet), existing ground water monitoring wells will not be used as primary air injection wells or as vapor MPs.

3.1 Site Layout

A general description of criteria for siting a central VW and vapor MPs are included in the protocol document (Hinchee et al., 1992). Figure 3.1 illustrates the proposed locations of the central VW and MPs at this site. The final locations of these wells may vary slightly from the proposed locations if significant fuel contamination is not observed in the boring for the VW. Based on site investigation data, the central VW should be located as close as possible to the aircraft mockup, near soil boring FTA-10. Soils in this area are expected to be oxygen depleted (<2%) due to high hydrocarbon levels, and increased biological activity should be stimulated by oxygen-rich soil gas ventilation during pilot test operations.



Source: U.S.G.S., 1993.

FIGURE 2.6

SITE MAP
MANZANO FIRE TRAINING AREA

KIRTLAND AFB, NEW MEXICO

ENGINEERING-SCIENCE, INC.
Denver, Colorado

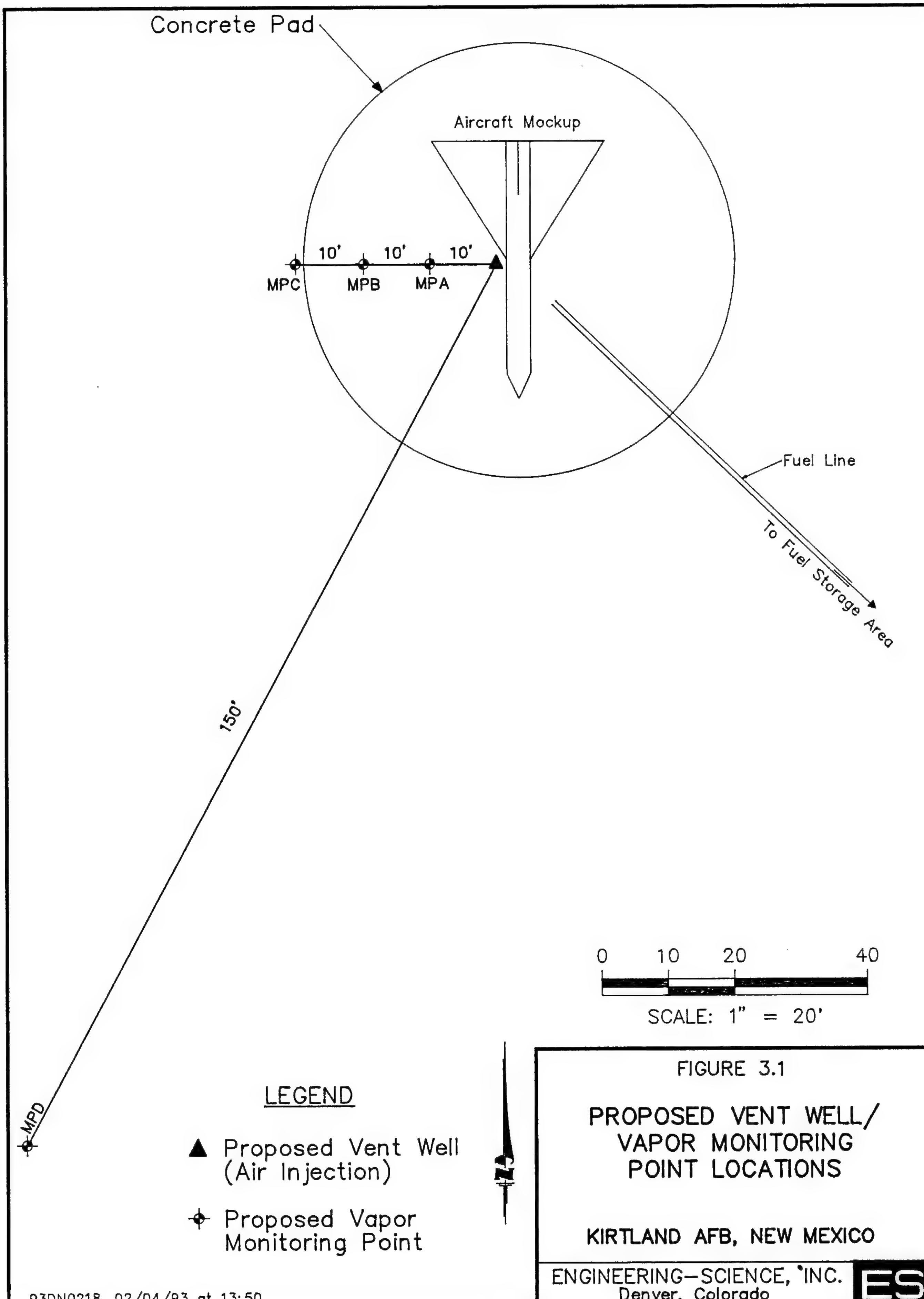


FIGURE 3.1

PROPOSED VENT WELL/ VAPOR MONITORING POINT LOCATIONS

KIRTLAND AFB, NEW MEXICO

ENGINEERING-SCIENCE, INC.
Denver, Colorado

Due to the relatively shallow depth of contamination at this site and the experience that ES has had with similar soil types, the potential radius of venting influence around the central air injection well is expected to be 20 to 30 feet. Three vapor MPs (MPA, MPB, and MPC) will be located within a 30-foot radial distance of the central VW. A fourth MP (MPD) will be located upgradient of the site and will be used to measure background levels of oxygen and carbon dioxide and to determine if natural carbon sources are contributing to oxygen uptake during the *in situ* respiration test.

3.2 Vent Well

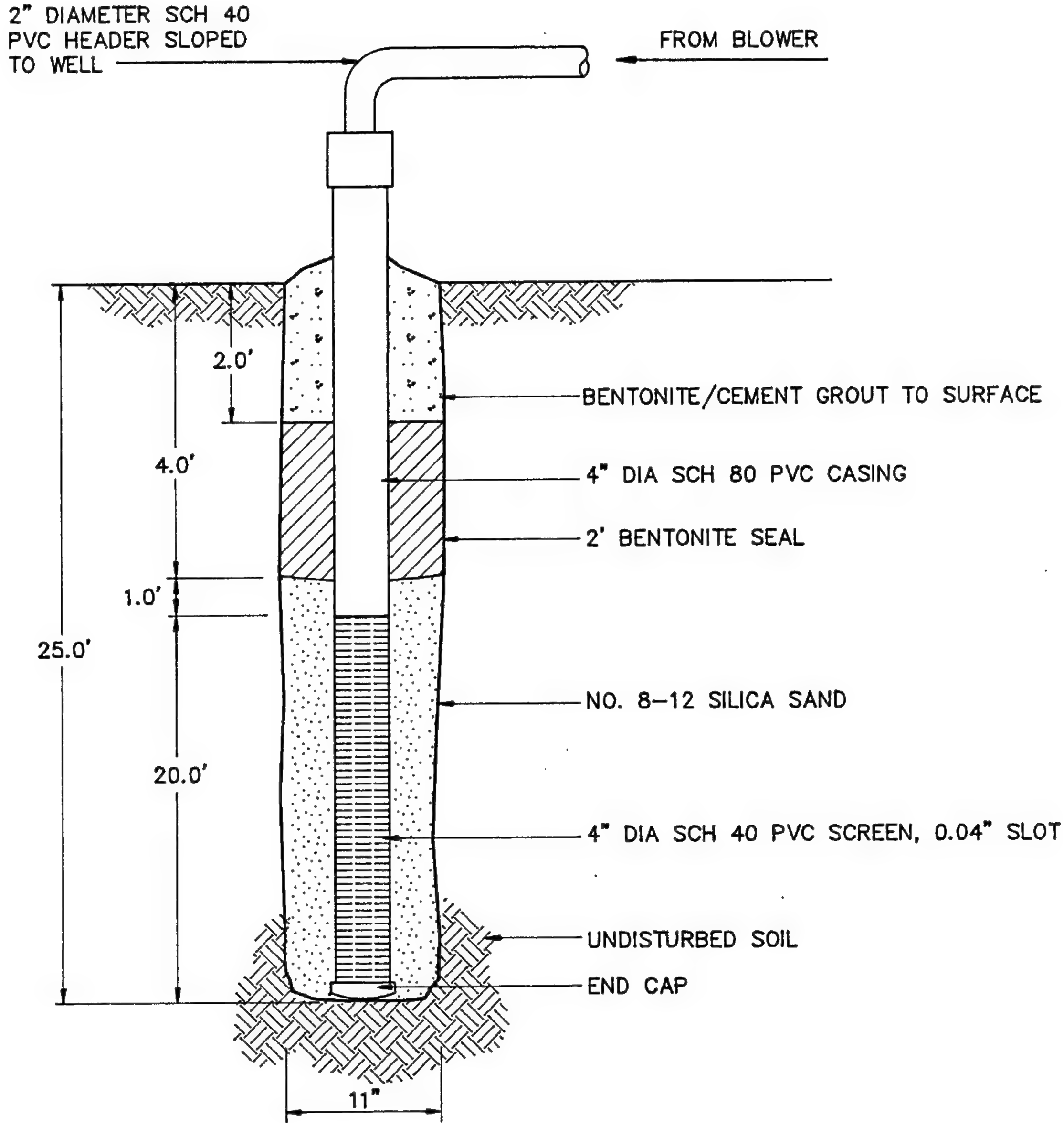
The VW will be constructed of 4-inch inside-diameter (ID) schedule 40 PVC, with a 20-foot interval of 0.02-inch slotted screen set at 5 to 25 feet bgs. The depth of the VW will be extended if significant contamination is evident below 25 feet. Flush-threaded PVC casing and screen with no organic solvents or glues will be used. The filter pack will be clean, well-rounded silica sand with a 8-12 grain size, and will be placed in the annular space of the screened interval. A 2-foot layer of bentonite pellets, hydrated in place with potable water, will be placed directly over the filter pack. This layer of pellets will prevent the addition of bentonite slurry from saturating the filter pack. A bentonite/cement grout will then be tremied into the remaining annular space above the bentonite pellets to produce an air-tight seal above the screened interval. A complete seal is critical to prevent injected air from short circuiting to the surface during the bioventing test. Figure 3.2 illustrates the proposed VW construction for this site.

3.3 Monitoring Points

A typical multi-depth vapor MP installation for this site is shown in Figure 3.3. Soil gas oxygen and carbon dioxide concentrations will be monitored at depth intervals of 5-7 feet, 11-13 feet and 18-20 feet at each location. Multi-depth monitoring will confirm that the entire soil profile is receiving oxygen and be used to measure fuel biodegradation rates at each depth. Actual monitoring point depths may be adjusted to correspond with actual contaminated soil depths. The spaces between monitoring intervals will be sealed with bentonite to isolate the intervals. As with the central VW, several inches of bentonite pellets will be used to shield the filter pack from rapid infiltration of bentonite slurry additions. Additional details on VW and MP construction are found in Section 4 of the protocol document.

3.4 Handling of Drill Cuttings

Cuttings will be collected in U.S. Department of Transportation (DOT) approved containers. The containers will be labeled, and then placed in the Kirtland AFB hazardous material storage area. Drill cuttings will become the responsibility of Kirtland AFB, or their designated contractor, and will be analyzed and disposed of in accordance with the current procedures for ongoing remedial investigations.



NOT TO SCALE

FIGURE 3.2

PROPOSED AIR INJECTION VENT WELL CONSTRUCTION FORMER FIRE TRAINING AREA

KIRTLAND AFB, NEW MEXICO

ENGINEERING–SCIENCE, INC.
Denver, Colorado

ES

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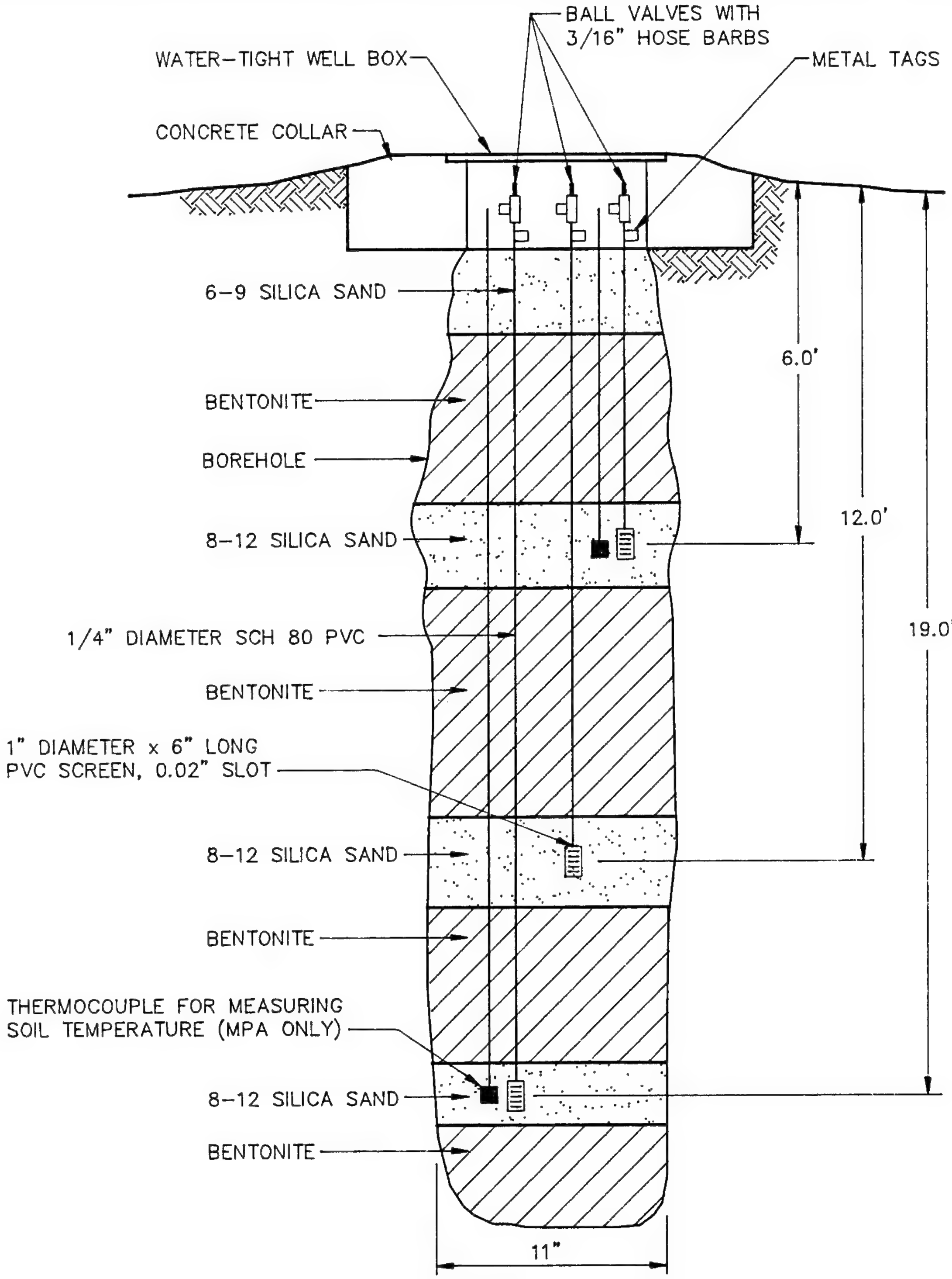


FIGURE 3.3

PROPOSED MONITORING POINT CONSTRUCTION DETAIL FORMER FIRE TRAINING AREA

KIRTLAND AFB, NEW MEXICO

ENGINEERING-SCIENCE, INC.
Denver, Colorado

93DN0214, 02/03/93 at 11:41

3.5 Soil and Soil Gas Sampling

3.5.1 Soil Samples

Three soil samples will be collected from the pilot test area during the installation of the VW and MPs. Sampling procedures will follow those outlined in the protocol document. One sample will be collected from the most contaminated interval of the VW boring, and one sample will be collected from the interval of highest apparent contamination in each of the borings for the two MPs closest to the VW. Soil samples will be analyzed for TRPH, benzene, toluene, ethylbenzene, and xylenes (BTEX), soil moisture, pH, particle size, alkalinity, total iron, and nutrients.

Samples for TRPH and BTEX analysis will be collected using a split-spoon sampler containing brass tube liners. Soil samples collected in the brass tubes for TRPH and BTEX analyses will be immediately trimmed, and the ends will be sealed with aluminum foil or Teflon® fabric held in place by plastic caps. Soil samples collected for physical parameter analyses will be placed into glass sample jars or other appropriate sample containers specified in the base sample handling plan. Soil samples will be labelled following the nomenclature specified in the protocol document (Section 5), wrapped in plastic, and placed in a cooler for shipment. A chain-of-custody form will be filled out, and the cooler will be shipped to the ES laboratory in Berkeley, California for analysis. This laboratory has been audited by the Air Force and meets all quality assurance/quality control (QA/QC) and certification requirements for the State of California.

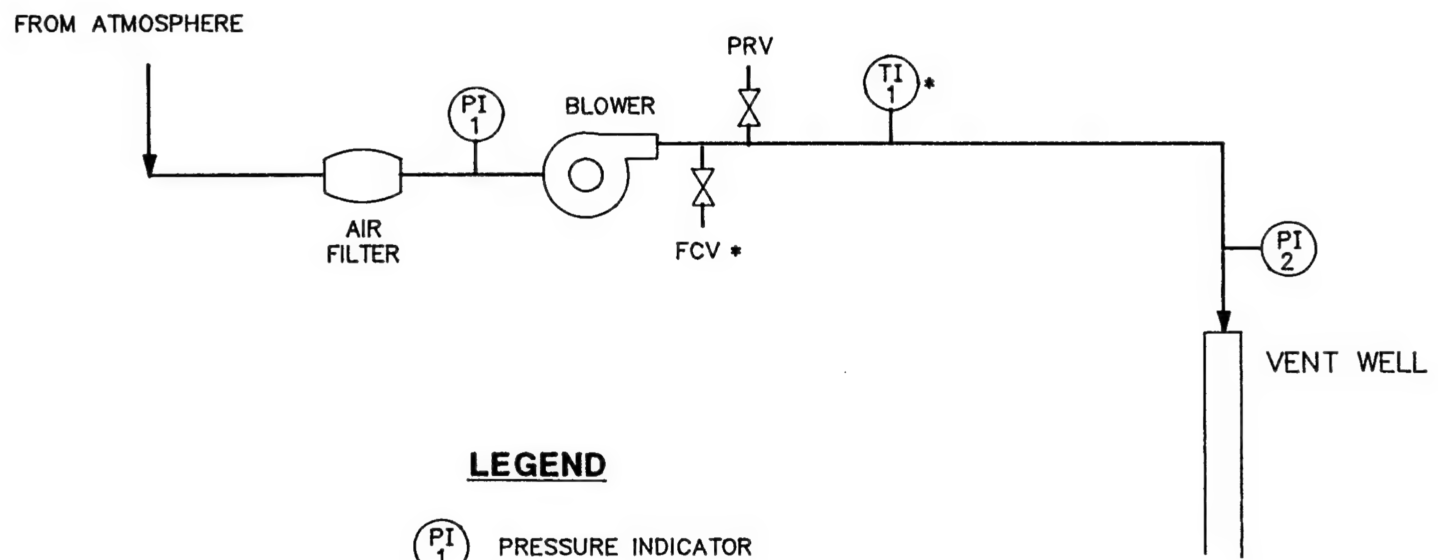
3.5.2 Soil Gas Samples

A total hydrocarbon vapor analyzer will be used during drilling to screen split-spoon samples for intervals of high fuel contamination. Initial soil gas samples will be collected in SUMMA® canisters in accordance with the *Bioventing Field Sampling Plan* (Engineering-Science, Inc. 1992) from the VW and from the MPs closest to and furthest from the VW. Additionally, these soil gas samples will be used to predict potential air emissions, to determine the reduction in BTEX and total volatile hydrocarbons (TVH) during the 1-year test, and to detect any migration of these vapors from the source area.

Soil gas sample canisters will be placed in a small cooler and packed with foam pellets to prevent excessive movement during shipment. Samples will not be sent on ice to prevent condensation of hydrocarbons. A chain-of-custody form will be filled out, and the cooler will be shipped to the Air Toxics, Inc. laboratory in Rancho Cordova, California for analysis.

3.6 Blower System

A 2.5-horsepower regenerative blower capable of injecting air at 30-40 scfm will be used to conduct the initial air permeability test. Figure 3.4 is a schematic of a typical air injection system used for pilot testing. The maximum power requirement anticipated for this pilot test is 230-volt, single-phase, 30-amp service. Additional details on power supply requirements are described in Section 5.0, Base Support Requirements.



LEGEND

PI 1 PRESSURE INDICATOR

TI 1 TEMPERATURE INDICATOR

FCV FLOW CONTROL VALVE

PRV PRESSURE RELIEF VALVE

* OPTIONAL

93DN0215, 02/03/93 at 11:46

FIGURE 3.4

PROPOSED BLOWER SYSTEM INSTRUMENTATION DIAGRAM FOR AIR INJECTION FORMER FIRE TRAINING AREA

KIRTLAND AFB, NEW MEXICO

ENGINEERING–SCIENCE, INC.
Denver, Colorado

3.7 In Situ Respiration Test

The objective of the *in situ* respiration test is to determine the rate at which soil bacteria degrade petroleum hydrocarbons. Respiration tests will be performed at selected MPs where bacteria biodegradation of hydrocarbons is indicated by low oxygen levels and elevated carbon dioxide concentrations in the soil gas. A 1 cfm pump will be used to inject air into the selected MP depth intervals containing low levels (<2%) of oxygen. A 20-hour air injection period will be used to oxygenate local contaminated soils. At the end of the 20-hour air injection period, the air supply will be cut off, and oxygen and carbon dioxide levels will be monitored for the following 48 to 72 hours. The decline in oxygen and increase in carbon dioxide concentrations over time will be used to estimate rates of bacterial degradation of fuel residuals. Helium will also be injected at two MPs to estimate oxygen loss due to diffusion rather than biological respiration. Additional details on the *in situ* respiration test are found in Section 5.7 of the protocol document.

3.8 Air Permeability Test

The objective of the air permeability test is to determine the extent of the subsurface that can be oxygenated using one air injection VW. Air will be injected into the 4-inch-diameter VW at 30-40 scfm using the blower unit, and pressure response will be measured at each MP with differential pressure gauges to determine the region influenced by the unit. Oxygen will also be monitored in the MPs to verify that oxygen levels in the soil increase as the result of air injection. One air permeability test lasting 4 to 8 hours will be performed. Additional details on the air permeability test are found in Section 5.6.2 of the protocol document.

3.9 Installation of 1-Year Pilot Test Bioventing System

Long-term bioventing systems will be installed at the former fire training area. The base will be requested to provide support to an ES subcontractor in obtaining the necessary power at the site, including 230-volt, 30-amp, single-phase service and a breaker box with one 230-volt receptacle and two 110-volt receptacles. Depending on the availability of a base electrician, a base electrician or a licensed electrician subcontracted to ES will assist in wiring the blowers to line power. The blower will be housed in a small, prefabricated shed to provide protection from the weather. The system will be in operation for 1 year, and every 6 months ES personnel will conduct *in situ* respiration tests to monitor the long-term performance of this bioventing system. Weekly system checks will be performed by Kirtland AFB personnel. If required, major maintenance of the blower unit will be performed by ES-Denver personnel. Detailed blower system information and a maintenance schedule will be included in the operation and maintenance (O&M) manual provided to the base. More detailed information regarding the test procedures can be found in the protocol document.

4.0 EXCEPTIONS TO PROTOCOL PROCEDURES

The procedures that will be used to measure the air permeability of the soil and *in situ* respiration rates are described in Sections 4 and 5, respectively, of the

protocol document (Hinchee et al., 1992). No exceptions to the protocol are anticipated.

5.0 BASE SUPPORT REQUIREMENTS

The following base support is needed prior to the arrival of the drilling subcontractor and the ES pilot test team:

- Assistance in obtaining drilling and digging permits.
- Provide support to an ES electrical subcontractor to establish power at the site. Power requirements include 230-volt, 30-amp, single-phase service and a breaker box with one 230-volt receptacle and two 110-volt receptacles.
- Provision of any paperwork required to obtain gate passes and security badges for approximately three ES employees, two drillers, and an electrician (if a base electrician is not available). Vehicle passes will be needed for one truck and trailer, and a drill rig.

During the initial testing, the following base support is needed:

- Twelve square feet of desk space and a telephone in a building located as close to the site as practical.
- The use of a facsimile machine for transmitting 15 to 20 pages of test results.
- A decontamination pad where the driller can clean augers between borings.
- Acceptance of responsibility for drill cuttings from VW and MP borings, including any drum sampling to determine hazardous waste status. (If ES is to transfer custody of barrels to another contractor working on the base, assistance in arranging this transfer will also be needed.)

During the 1-year extended pilot test, base personnel will be required to perform the following activities:

- Check the blower system once per week to ensure that it is operating and to record the air injection pressure. ES will provide a brief training session on this procedure.
- If the blower stops working, notify Mr. Todd Wiedemeier or Mr. Doug Downey of ES-Denver, (303) 831-8100; or Mr. Jim Williams of AFCEE, (210) 536-5246.
- Arrange site access for an ES technician to conduct *in situ* respiration tests at approximately 6 months and 1 year after the initial pilot test.

6.0 PROJECT SCHEDULE

The following schedule is contingent upon approval of this pilot test work plan and completion of base support requirements.

Event	Date
Draft Test Work Plan to AFCEE/Kirtland AFB	10 February 1993
Begin Initial Pilot Test	15 March 1993
Interim Results Report	15 May 1993
Respiration Test	September 1993
Final Respiration Test	March 1993

7.0 POINTS OF CONTACT

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Fax (303) 831-8208

8.0 REFERENCES

Engineering-Science, Inc. 1981. Report covering Phase I of the Installation Restoration Program (IRP).

Engineering-Science, Inc. 1992. *Field Sampling Plan for AFCEE Bioventing.* Denver, Colorado. January.

Hinchee, R.E., S.K., Ong, R.N., Miller, D.C., Downey, and R. Frandt. 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing.* January.

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U.S. Geological Survey. 1993. Installation Restoration Program Stage 2B, Work Plan for Kirtland AFB, NM.

PART II

DRAFT INTERIM PILOT TEST RESULTS REPORT

FOR

FORMER FIRE TRAINING AREA (FT-13)

KIRTLAND AFB, NEW MEXICO

June 1993

Prepared for:

Air Force Center for Environmental Excellence
Brooks AFB, Texas

and

377th ABW/EM
Kirtland AFB, New Mexico

by:

Engineering-Science, Inc.
1700 Broadway, Suite 900
Denver, Colorado

PART II

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PART II

DRAFT
INTERIM PILOT TEST RESULTS REPORT
FOR FORMER FIRE TRAINING AREA (FT-13)
KIRTLAND AFB, NEW MEXICO

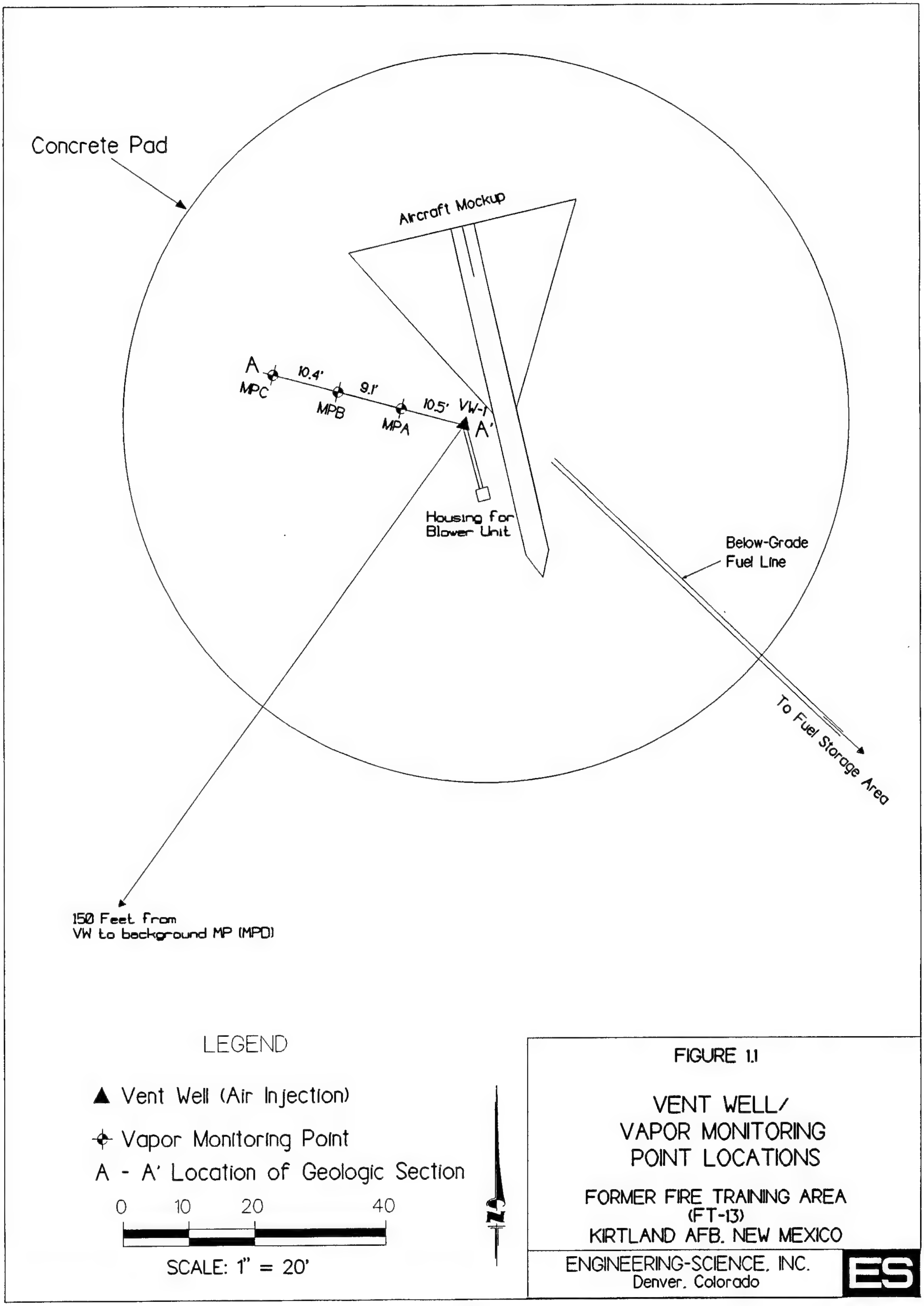
An initial bioventing pilot test was completed at former Fire Training Area FT-13 at Kirtland Air Force Base (AFB), New Mexico during the period 5 April through 12 April 1993. The purpose of Part II of this report is to describe the results of the initial pilot test at FT-13 and to make specific recommendations for extended testing to determine the long-term impact of bioventing on site contaminants. Descriptions of the history, geology, and contamination at Site FT-13 are contained in Part I of this report, the Bioventing Pilot Test Work Plan. These descriptions are based on the results of previous investigations at the site. Descriptions of the geology and contamination at the site based on the findings of the current investigation are included in this part of the report.

In addition to the activities performed at FT-13, preliminary soil gas screening activities were performed and an air injection vent well (VW) was installed at the former Manzano Fire Training Area FT-14. After additional soil gas surveys were conducted at the Manzano site, it was determined that further site characterization was necessary before a pilot-scale bioventing system could be installed. The activities performed at the Manzano site are described in Sections 1.1.2 and 2.1.2.

1.0 PILOT TEST DESIGN AND CONSTRUCTION

Installation of a VW, three vapor monitoring points (MPs), and a background MP took place at FT-13 on 5 April and 6 April 1993. Drilling services were provided by Enviro-Drill, Inc. of Albuquerque, New Mexico. Well installation and soil sampling activities were directed by the Engineering-Science, Inc. (ES) site manager, Mr. Todd Wiedemeier. The following sections describe the installation of the pilot-scale bioventing system at site FT-13 and the installation of a VW at FT-14. Descriptions of the final system configuration and as-built drawings of the blower system, the VW, the MPs (MPA, MPB, and MPC), and the background MP (MPD) at FT-13 are included in this section.

One VW, three MPs, one background MP, and one blower unit were installed at Site FT-13. Figure 1.1 shows the location of pilot test system components. Figure 1.2 is a geologic section prepared from lithologic logs compiled during bioventing



Concrete Pad
Aircraft Mockup
A
MPC
10.4'
MPB
9.1'
MPA
10.5'
VW-1
A'
Housing for
Blower Unit
Below-Grade
Fuel Line
To Fuel Storage Area
150 Feet from
VW to background MP (MPD)
LEGEND
Vent Well (Air Injection)
Vapor Monitoring Point
A - A' Location of Geologic Section
0 10 20 40
SCALE: 1" = 20'
N
FIGURE 1.1
VENT WELL/
VAPOR MONITORING
POINT LOCATIONS
FORMER FIRE TRAINING AREA
(FT-13)
KIRTLAND AFB, NEW MEXICO
ENGINEERING-SCIENCE, INC.
Denver, Colorado
ES

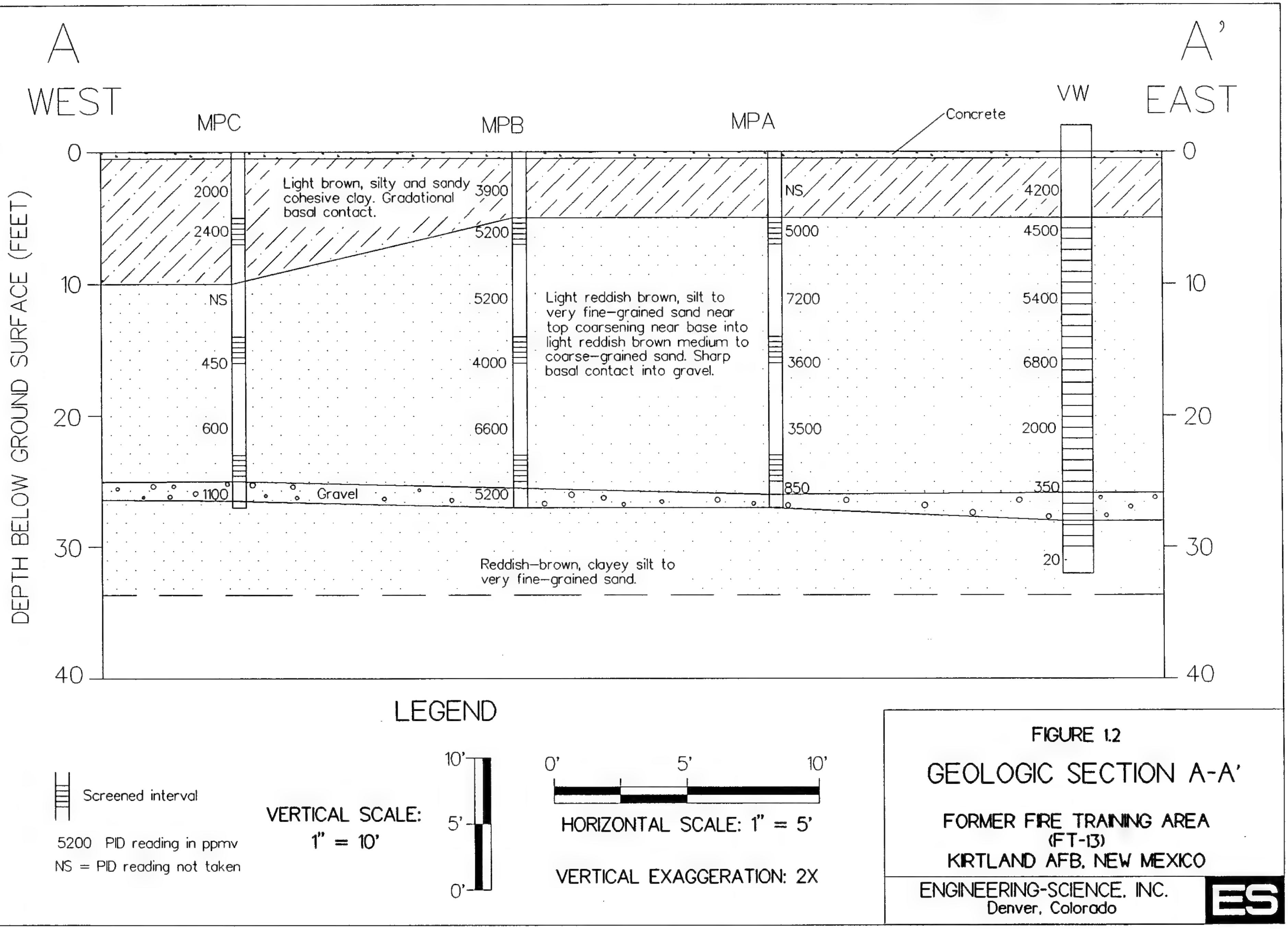


FIGURE 1.2

GEOLOGIC SECTION A-A'

FORMER FIRE TRAINING AREA
(FT-13)
KIRTLAND AFB, NEW MEXICO

system installation. The MPs and VW boring logs used to compile this section are included in Appendix A.

1.1 Air Injection Vent Wells

1.1.1 Air Injection Vent Well at FT-13

The air injection VW (VW-1) at FT-13 was installed following the procedures described in the Air Force Center for Environmental Excellence (AFCEE) bioventing protocol document (Hinchee et al., 1992). Figure 1.3 shows construction details for VW-1. The VW was installed in highly contaminated soils, with the screened interval extending from 5 feet below ground surface (bgs) to 30 feet bgs. The VW was constructed using 4-inch-diameter, schedule 40 polyvinyl chloride (PVC) casing, with 25 feet of 0.02-inch slotted schedule 40 PVC screen. The annular space between the well casing and borehole was filled with 8-12 sieve size Colorado silica sand from the bottom of the borehole to approximately 1 foot above the well screen. Twenty inches of sodium bentonite pellets were placed above the sand. To obtain a good seal, the bentonite was hydrated in place in 6-inch lifts. Concrete was placed above the sodium bentonite seal and extends to the surface. The top of the well extends approximately 2 feet above grade and was completed with a 4-inch-diameter PVC tee with a screw cap to allow future access to the well.

1.1.2 Air Injection Vent Well at Manzano Site (FT-14)

Based on the results of a preliminary soil gas survey at the Manzano site (Section 2.1.2.2), an air injection VW (VW-2) was installed following the procedures described in the AFCEE bioventing protocol document (Hinchee et al., 1992). Figure 1.4 shows the location of VW-2, which was installed in the western-most of two fire training pits. Figure 1.5 shows construction details for VW-2. The VW was installed in contaminated soils with the screened interval extending from 9 to 29 feet bgs. The VW was constructed using 4-inch-diameter, schedule 40 PVC casing, with 20 feet of 0.02-inch slotted schedule 40 PVC screen. The annular space between the well casing and borehole was filled with 8-12 sieve size Colorado silica sand from the bottom of the borehole to approximately 2 feet above the well screen. Three feet of sodium bentonite pellets were placed above the sand. To obtain a good seal, the bentonite was hydrated in place in 6-inch lifts. Concrete was placed above the sodium bentonite seal and extends to the surface. The top of the well extends approximately 1 foot above grade and was capped with a PVC slip cap to allow future access to the well. No additional bioventing system components were installed at the Manzano site.

1.3 Vapor Monitoring Points (FT-13)

The vapor MP screens for MPA, MPB, and MPC were installed at 6-, 15-, and 24-foot depths. Figure 1.6 shows the construction details for these MPs. Each was constructed using a 6-inch section of 1-inch-diameter PVC well screen and a 0.25-inch schedule 80 PVC riser pipe extending to the ground surface. At the top of each riser, a ball valve and a 3/16-inch hose barb were installed. The top of each MP was completed with a flush-mounted metal well protector set in a concrete base.

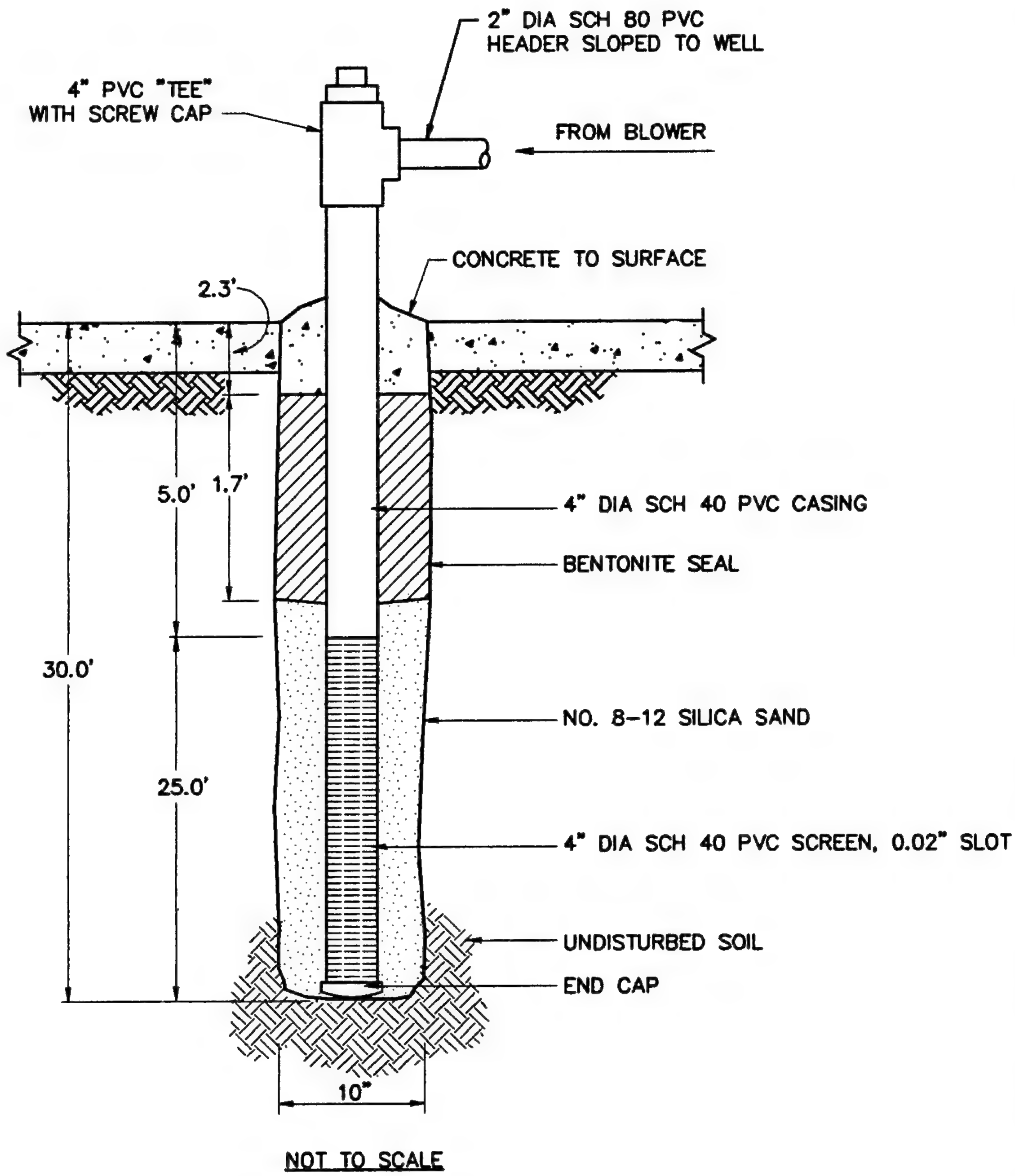


FIGURE 1.3
AS-BUILT INJECTION/VENT WELL CONSTRUCTION DETAIL FOR VW-1

FORMER FIRE TRAINING AREA (FT-13)

KIRTLAND AFB, NEW MEXICO

ENGINEERING-SCIENCE, INC.
Denver, Colorado

ES

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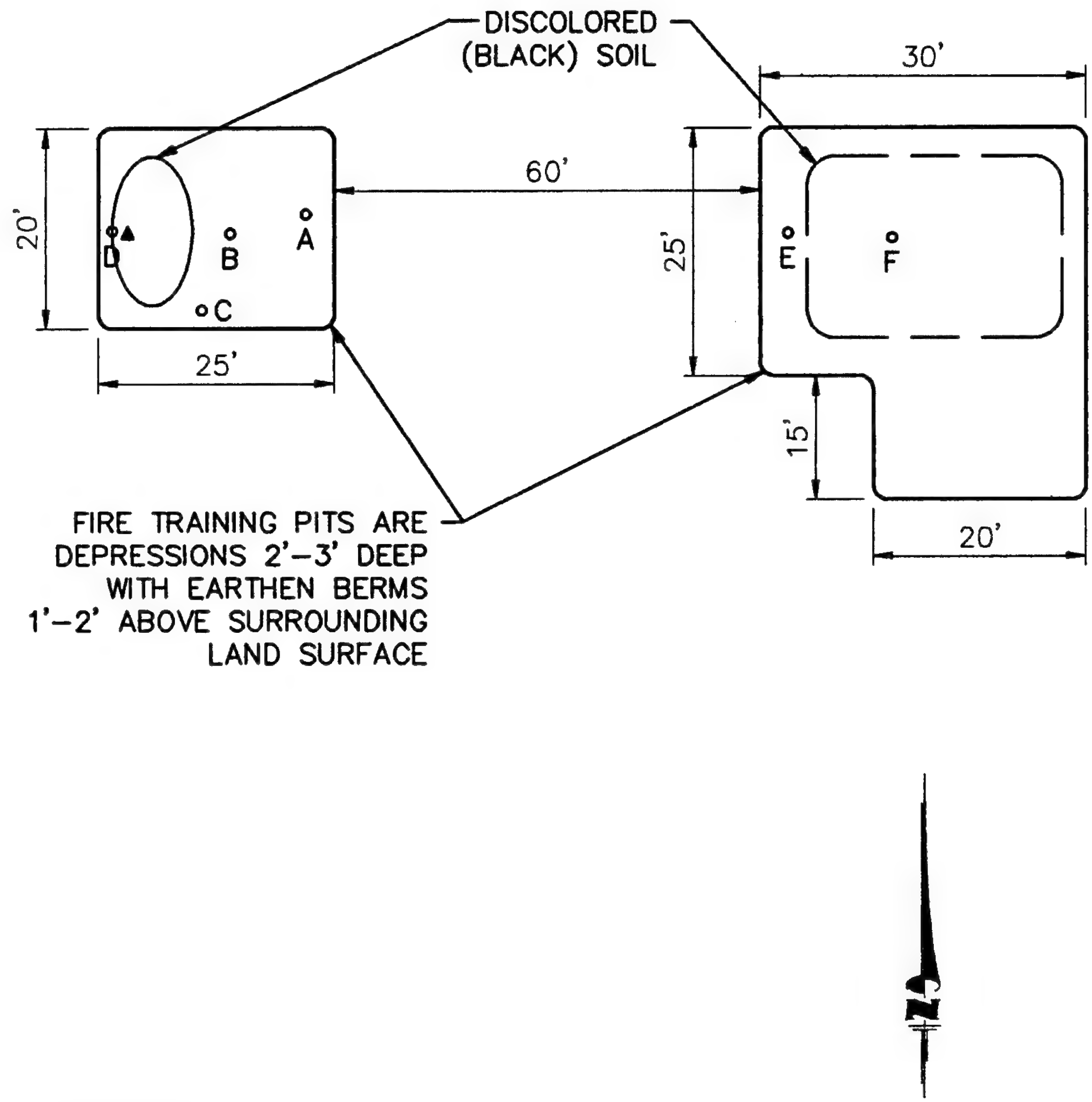

NOT TO SCALE

LEGEND

- o SOIL GAS SAMPLING LOCATION
- ▲ VENT WELL

FIGURE 1.4

SOIL GAS SURVEY AND VENT WELL LOCATION MAP

MANZANO FIRE TRAINING AREA (FT–14)

KIRTLAND AFB, NEW MEXICO

ENGINEERING–SCIENCE, INC.
Denver, Colorado

ES

93DN0493, 06/09/93 at 08:49

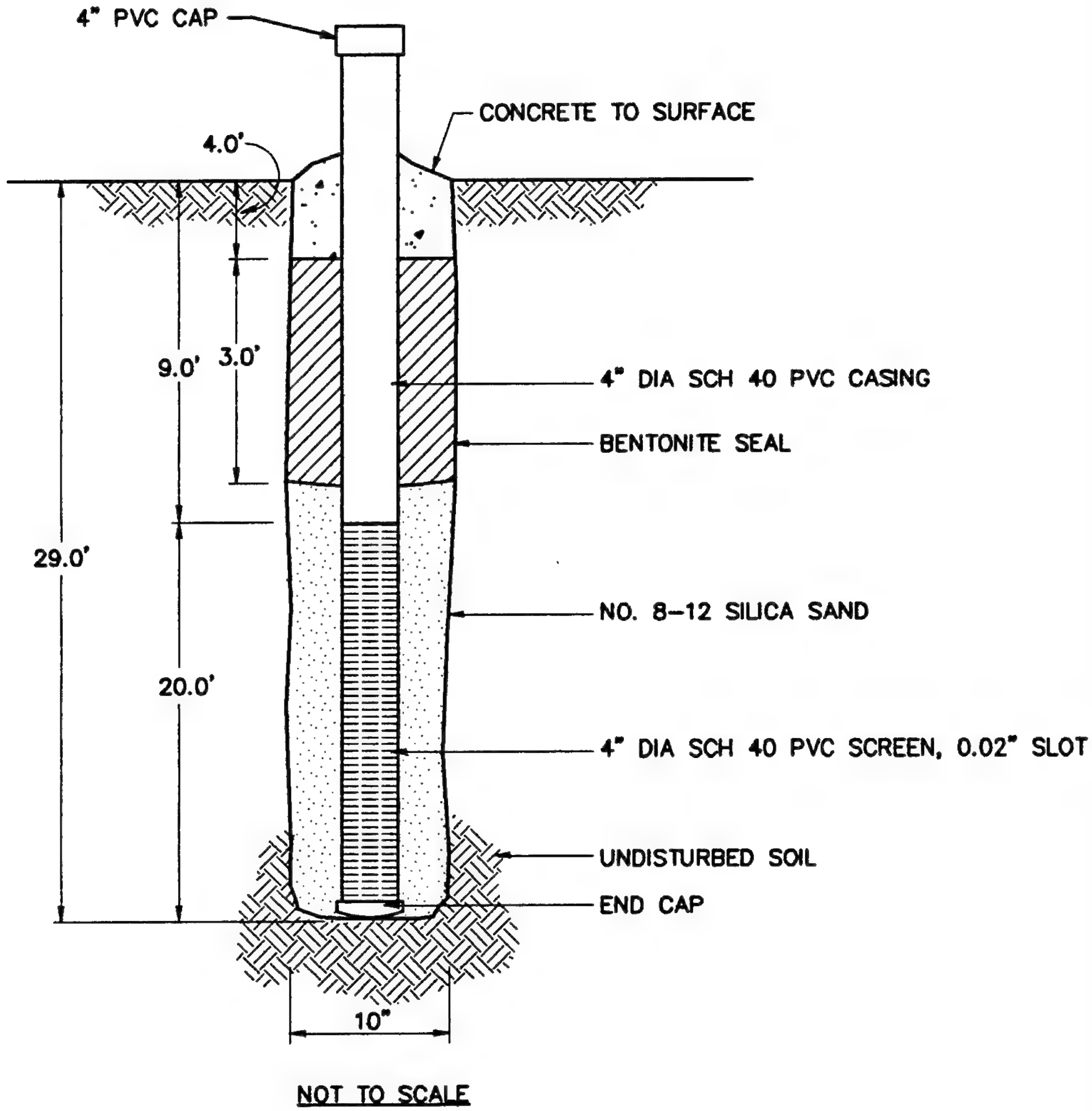

FIGURE 1.5
AS-BUILT INJECTION/VENT WELL CONSTRUCTION DETAIL VW-2

MANZANO FIRE TRAINING AREA (FT-14)
KIRTLAND AFB, NEW MEXICO

ENGINEERING-SCIENCE, INC.
Denver, Colorado

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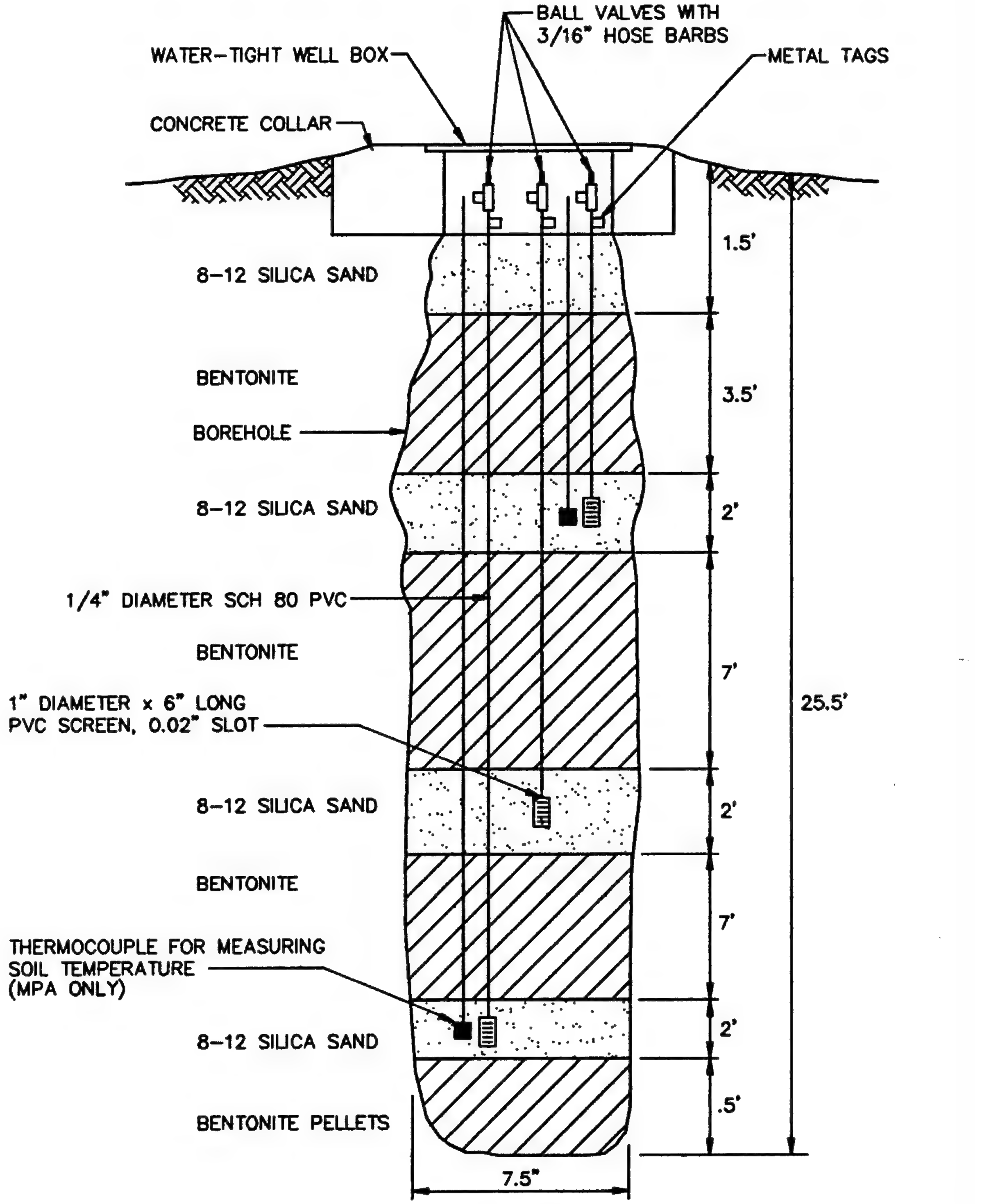

FIGURE 1.6

AS-BUILT MONITORING POINT CONSTRUCTION DETAIL FOR MPA, MPB, AND MPC

FORMER FIRE TRAINING AREA (FT-13)
KIRTLAND AFB, NEW MEXICO

ENGINEERING-SCIENCE, INC.
Denver, Colorado

ES

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Thermocouples were installed at the 6- and 24-foot depths at MPA to measure soil temperature variations.

A multi-depth background MP (MPD) screened at approximately 6, 15, and 21.5 feet bgs was placed 150 feet southwest of the VW (Figure 1.7). This MP was constructed using a 6-inch section of 1-inch-diameter PVC well screen and a 0.25-inch PVC riser pipe extending to the ground surface. At the top of each riser, a ball valve and a 3/16-inch hose barb were installed. The top of MPD was completed with a flush-mounted metal well protector set in a concrete base. Figure 1.7 shows the construction details for MPD.

1.4 Blower Unit (FT-13)

A 1-horsepower Gast® regenerative blower unit was used for the initial pilot test, and was installed at the Site FT-13 for the extended pilot test. The unit is powered by 230-volt, single-phase, 30-amp line power from a newly installed breaker box. The 1-horsepower extended pilot test blower was configured to inject approximately 40 standard cubic feet per minute (scfm) for the extended pilot test. The configuration, instrumentation, and specifications for the initial pilot test and extended pilot test units are shown on Figure 3.5 (Part I) and Figure 1.8, respectively. Prior to departing from the site, ES engineers provided operations and maintenance (O&M) instructions and blower maintenance manual to base personnel. A copy of the instructions is provided in Appendix B.

2.0 PILOT TEST SOIL AND SOIL GAS SAMPLING RESULTS

2.1 Sampling Results

This section presents the results of sampling activities at FT-13 and the Manzano fire training area FT-14.

2.1.1 Sampling Results for FT-13

2.1.1.1 Soil Sampling

Shallow soils at this site consist of a 5- to 10-foot interval of light brown, silty and sandy, damp, cohesive clay (Figure 1.2) with a strong hydrocarbon odor and patches of black hydrocarbon staining. This material grades downward into a 15- to 20-foot thick sequence, coarsening downward with light reddish-brown silt near the top of the interval and clayey and silty medium- to coarse-grained sand near the base. These silts and sands are damp, have a moderate to strong petroleum hydrocarbon odor, and have a sharp contact with underlying gravel deposits. Underlying the silts and sands is a 2-foot-thick interval of reddish-brown, very poorly sorted, damp, silty and sandy gravel with a weak to moderate petroleum hydrocarbon odor. These gravels are abruptly underlain by reddish-brown, clayey silt to very fine-grained sand of indeterminate thickness. Near the VW, this sediment had no hydrocarbon odor. Figure 1.2 is a geologic section which graphically illustrates the stratigraphic relationships between the shallow soils at site FT-13. The location of this section is shown on Figure 1.1. Boring logs from boreholes drilled at site FT-13 are included in Appendix A.

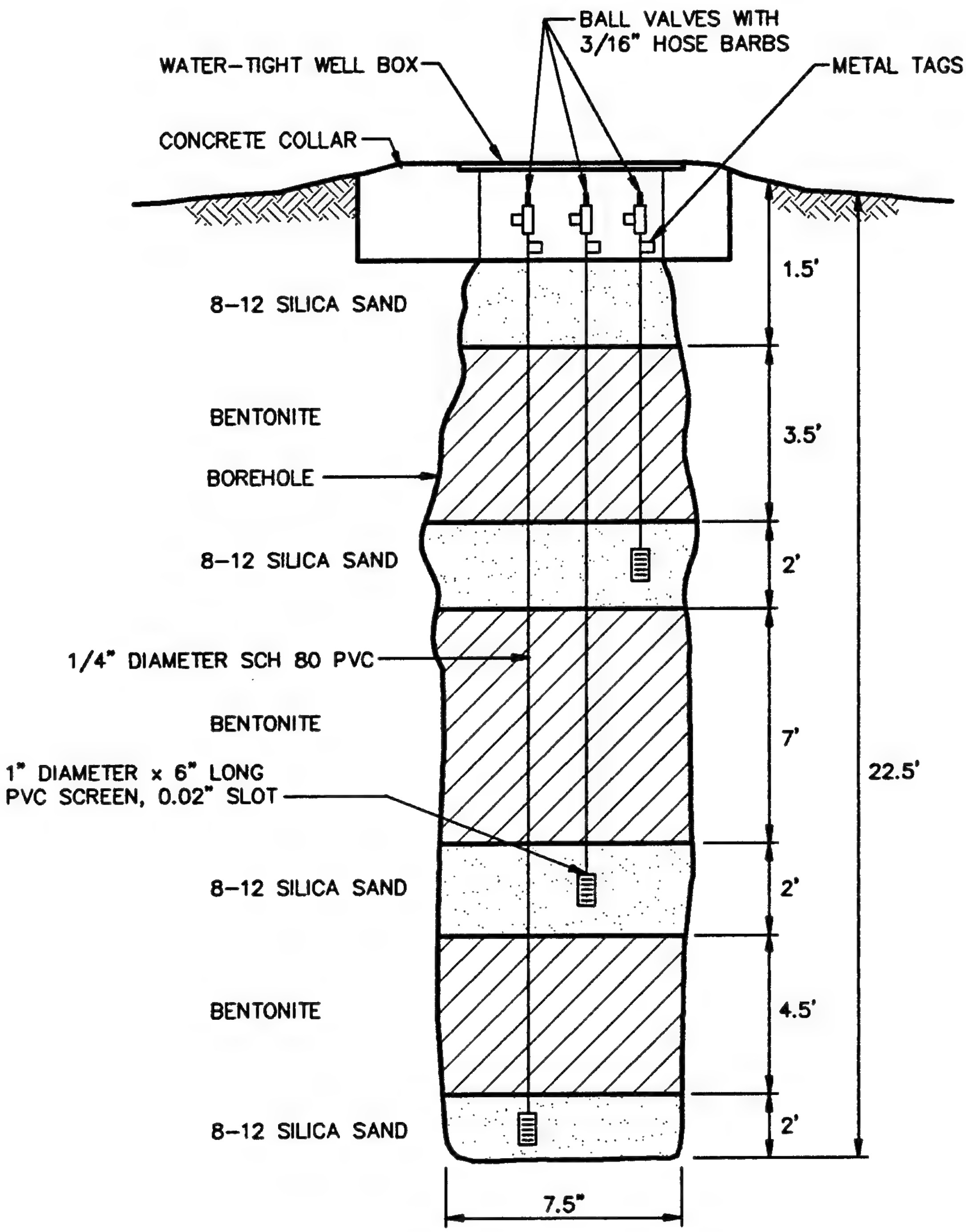


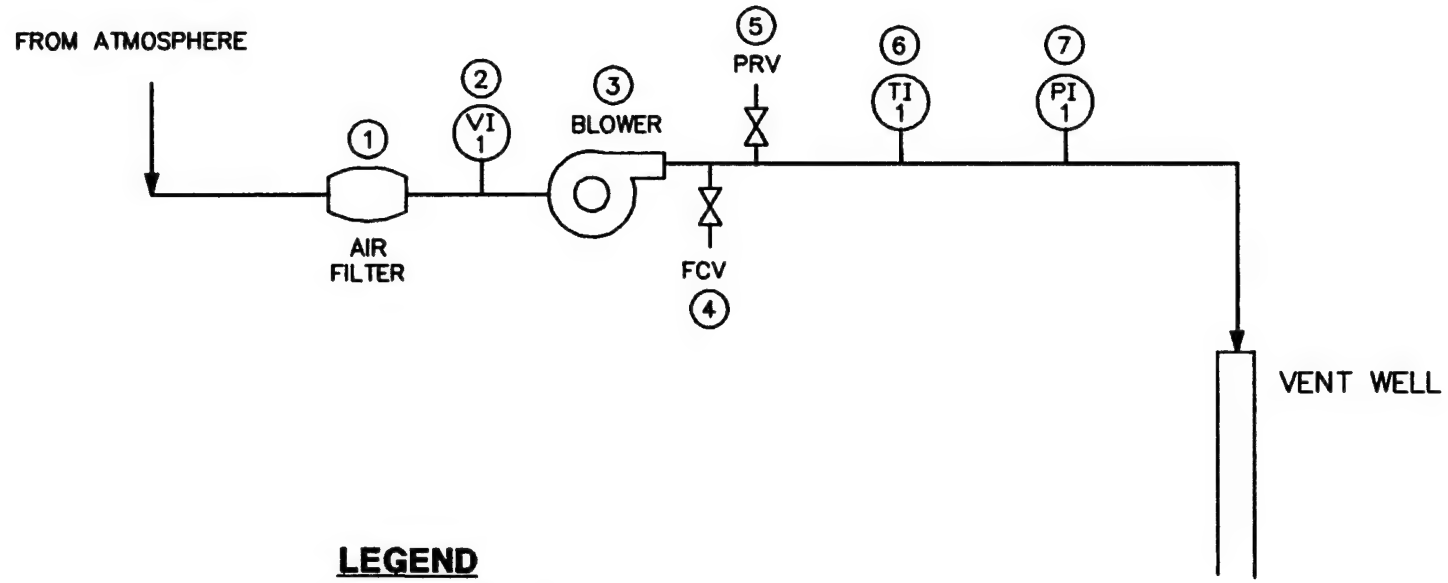
FIGURE 1.7

AS-BUILT MONITORING POINT CONSTRUCTION DETAIL FOR BACKGROUND MONITORING POINT (MPD) FORMER FIRE TRAINING AREA (FT-13)

KIRTLAND AFB, NEW MEXICO

ENGINEERING-SCIENCE, INC.
Denver, Colorado

ES



LEGEND

1. INLET AIR FILTER – SOLBERG® F-30P-150
2. VACUUM GAUGE (in. H_2O)
3. 1-HP BLOWER – GAST® R4110N-50
4. FLOW CONTROL (BLEED) VALVE – 1 1/2" GATE
5. AUTOMATIC PRESSURE RELIEF VALVE
6. TEMPERATURE GAUGE (°F)
7. PRESSURE GAUGE (in. H_2O)

93DN0492, 06/09/93 at 08:12

FIGURE 1.8
AS-BUILT BLOWER SYSTEM INSTRUMENTATION DIAGRAM FOR AIR INJECTION FORMER FIRE TRAINING AREA (FT-13)

KIRTLAND AFB, NEW MEXICO

ENGINEERING-SCIENCE, INC.
Denver, Colorado

Near the VW, hydrocarbon contamination appears to be confined to the upper 30 feet of soil. In general, the total depth of contamination appears to increase outward from the VW until a distance of approximately 25 feet, at which point the level of contamination begins to decrease (Figure 1.2) Contaminated soils were identified based on visual appearance, odor, and volatile organic compound (VOC) field screening results. With the exception of the background MP, heavily contaminated soils were encountered in the VW and all MP boreholes.

Soil samples for laboratory analysis were collected from split-spoon samplers and immediately transferred to brass sample containers. Soil samples were screened for VOCs using a photoionization detector (PID) and the headspace procedure to help quantify the presence of contamination. The headspace procedure consists of filling a glass jar approximately 75 percent full with a portion of the soil sample collected using the split-spoon sampler and covering the jar with aluminum foil. The sample is kept at a constant temperature of approximately 70 degrees Fahrenheit for 2 hours to allow the contained soil-liquid-vapor system to attain equilibrium. The aluminum foil is then punctured with the probe on a PID and the vapor-phase VOC content of the sample's headspace is measured and recorded. The results of these PID headspace tests are presented on Figure 1.2.

Soil samples for laboratory analysis were collected from a depth of 2 to 4 feet bgs in the VW, 2 to 4 feet bgs in MPA, 5 to 7 feet bgs in MPB, and 15 to 17 feet bgs in MPD. Soil samples were shipped via Federal Express® to the Pace, Inc. laboratory in California for chemical and physical analyses. Soil samples were analyzed for total recoverable petroleum hydrocarbons (TRPH); benzene, toluene, ethylbenzene, and xylenes (BTEX); iron; alkalinity; total Kjeldahl nitrogen (TKN); and several physical parameters. The results of these analyses are presented in Table 2.1.

2.1.1.2 Soil Gas Sampling

Soil gas samples were collected by extracting soil gas from the completed VW, from the 14- to 16-foot interval in MPA, and from the 23- to 25-foot interval in MPC. Soil gas samples were shipped via Federal Express® to Air Toxics, Inc. in Rancho Cordova, California for total volatile hydrocarbon (TVH) and BTEX analyses. The results of these analyses are presented in Table 2.1.

2.1.2 Sampling Results for FT-14

2.1.2.1 Soil Sampling

Based on limited soil sampling (one borehole), shallow soils at the Manzano site consist of 22 feet of brown, clayey, silty, and sandy gravel with a 5-foot-thick interbed of brown, silty, sandy, and gravelly clay. The first 6 inches of this soil contains an oily black sludge which has a strong petroleum odor. These deposits are underlain by a reddish brown clayey, sandy, and gravelly silt of indeterminate thickness. Boring logs from boreholes drilled at site FT-13 are included in Appendix A.

Near VW-2, hydrocarbon contamination appears to be confined to the upper 30 feet of soil. Contaminated soils were identified based on visual appearance, odor,

TABLE 2.1
SOIL AND SOIL GAS ANALYTICAL RESULTS
FORMER FIRE TRAINING AREA (FT-13)
KIRTLAND AFB, NEW MEXICO

Analyte (Units)*	Sample Location-Depth (feet below ground surface)				
Soil Hydrocarbons	VW (15-17')	MPA (2-4')	MPB (5-7')	MPC (10-12')	MPD (15-17')
TRPH (mg/kg)	6,534	1,200	1,338	ND**	ND
Benzene (mg/kg)	ND	ND	ND	ND	ND
Toluene (mg/kg)	13	3.4	20	7	0.0016
Ethylbenzene (mg/kg)	18	5.8	14	ND	0.0004
Xylenes (mg/kg)	110	38	80	12	ND
Soil Organic Compounds***				MPC (10-12')	
Acetone (ug/Kg)				320	
2-Butanone (ug/Kg)				140	
2-Hexanone (ug/Kg)				7	
4-Methyl-2-pentanone (ug/Kg)				29	
Toluene (ug/Kg)				7	
Total Xylenes (ug/Kg)				12	
Soil Inorganics	VW (15-17')	MPA (2-4')	MPB (5-7')	MPC (10-12')	MPD (15-17')
Iron (mg/kg)	10,000	6,440	13,000	14,900	11,600
Alkalinity (mg/kg as CaCO3)	290	330	390	460	240
pH (standard units)	8.4	8.1	8.4	8.6	8.3
TKN (mg/kg)	NA****	63	59	66	44
Phosphates (mg/kg)	NS	210	350	310	330
Soil Physical Parameters	VW (15-17')	MPA (2-4')	MPB (5-7')	MPC (10-12')	MPD (15-17')
Moisture (wt. %)	7.6	16.1	10.7	10.4	6.5
Gravel (%)	NA	1.6	1.3	0.5	3.9
Sand (%)	NA	8.4	46	51	65
Silt (%)	NA	42.5	30	29	27
Clay (%)	NA	37.5	22.7	19.5	4.1
Soil Gas Hydrocarbons	VW (5-30')	MPA (15')		MPC (24')	
TVH (ppmv)	870	16,000		22,000	
Benzene (ppmv)	0.63	45		12	
Toluene (ppmv)	5.7	110		53	
Ethylbenzene (ppmv)	1.8	9.1		14	
Xylenes (ppmv)	7.2	33		63	
Soil Temperature (deg F)	MPA (6')	MPA (24')			
	54.6	62.1			

* TRPH=total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram; TVH=total volatile hydrocarbons; ppmv=parts per million, volume per volume; CaCO3=calcium carbonate; TKN=total Kjeldahl nitrogen.

** ND=not detected.

*** By GC/MS Method 8240.

**** NA=not analyzed.

and VOC field screening results. Contaminated soils were encountered to a depth of approximately 28 feet in VW-2.

Soil samples for laboratory analysis were collected from split-spoon samplers and immediately transferred to brass sample containers. Soil samples were screened for VOCs using the headspace procedure described above in Section 2.1.1.1 to help quantify the presence of contamination. The results of these headspace tests are included on the boring log presented in Appendix A.

One soil sample for laboratory analysis was collected from a depth of 2 to 4 feet bgs in VW-2. This sample was shipped via Federal Express® to the Pace, Inc. laboratory for chemical and physical analyses. This soil sample was analyzed for TRPH; BTEX; iron; alkalinity; TKN; and several physical parameters. The results of these analyses are presented in Table 2.2.

2.1.2.2 Soil Gas Survey (FT-14)

Limited soil gas surveying was conducted at the Manzano fire training area FT-14 to help determine the extent of natural degradation occurring at the site. Soil gas surveys were conducted at this site in two phases. Phase one was limited to taking soil gas samples at three points. The low oxygen levels found in the western fire training pit indicated that biodegradation of fuel hydrocarbons was probably occurring (points C and D in Figure 1.4 and Table 2.2). To help determine the magnitude and vertical extent of contamination at this site, an exploratory borehole was drilled. Soil sampling performed during the drilling of this boring indicated that contamination at FT-14 was potentially limited in vertical extent (Appendix A). However, because the borehole was in the area of highest known contamination, VW-2 was installed at the Manzano site. After the VW was installed, phase two soil gas surveying was conducted to help delineate the lateral extent of contamination. The results of this phase of soil gas sampling suggested that the contamination present at FT-14 is potentially of such limited extent that bioventing is not warranted (points A, B, E, and F in Figure 1.4 and Table 2.2). For this reason, additional drilling activities were suspended pending the results of additional site characterization activities scheduled for this site.

2.2 Exceptions To Test Protocol Document Procedures and the Part I Work Plan

Procedures described in the protocol document (Hinchee et al., 1992) were used to complete the pilot test at Site FT-13. Exceptions to the protocol document include:

- Bentonite seals in the MPs were hydrated in place instead of using a bentonite slurry to assure long-term integrity of the seals.
- At the request of the EPA, respiration tests will be conducted 4 times per year.
- In order to better define soil contamination, headspace tests were conducted on the majority of the soil samples. The headspace test was not conducted if the amount of soil collected during sampling was prohibitively small.

TABLE 2.2
SOIL AND SOIL GAS ANALYTICAL RESULTS
MANZANO FORMER FIRE TRAINING AREA (FT-14)
KIRTLAND AFB, NEW MEXICO

Analyte (Units)*	Sample Location-Depth (feet below ground surface)								
Soil Hydrocarbons	**VW-2 (2-4')**								
TRPH (mg/kg)	7,869								
Benzene (mg/kg)	ND								
Toluene (mg/kg)	ND								
Ethylbenzene (mg/kg)	0.79								
Xylenes (mg/kg)	3.7								
Soil Gas Survey	**VW-2 (8-28')**	**A (7')**	**B (5.5')**	**B (8.5')**	**C (8.5')**	**D (8.5')**	**E (8.5')**	**F (5.5')**	**F (8.5')**
TVH (ppmv)	NS***	NS	NS	NS	NS	360	NS	200	200
Oxygen (%)	2.8	13.5	11	10	4	2	18	20	20
Carbon Dioxide (%)	17.7	7.8	9.5	8.5	15	NS	1.5	NS	NS
Soil Inorganics	**VW-2 (2-4')**								
Iron (mg/kg)	26,200								
Alkalinity (mg/kg as CaCO3)	380								
pH (standard units)	7.0								
TKN (mg/kg)	200								
Phosphates (mg/kg)	1,000								
Soil Physical Parameters	**VW-2 (2-4')**								
Moisture (wt. %)	11.3								
Gravel (%)	21								
Sand (%)	57								
Silt (%)	17								
Clay (%)	5								

* TRPH=total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram; TVH=total volatile hydrocarbons; ppmv = parts per million, volume per volume; CaCO3=calcium carbonate; TKN=total Kjeldahl nitrogen.
** ND=not detected.
*** NS=not sampled.

- To confirm that the source of contamination was dominantly JP-4, EPA Method 8240 was run on one soil sample collected from FT-13.

Procedures described in the Part I Work Plan were used to complete the pilot test at sites FT-13 and FT-14. Exceptions to the work plan document include:

- The extent of work completed at FT-14 was limited to a soil gas survey and installation of a VW (VW-2).
- The VW at site FT-13 went deeper than specified in the work plan because contamination was observed at a greater depth than anticipated. Because of this, the MPs also went deeper than planned.
- The results of headspace testing indicate that small amounts of contamination may be present in MPD. Laboratory analysis of soil from this borehole indicate that contamination is minimal at the 15-17 foot depth interval.

2.3 Field QA/QC Results

Field quality assurance/quality control (QA/QC) samples were not collected or required at FT-13 or FT-14.

3.0 PILOT TEST RESULTS

3.1 Initial Soil Gas Chemistry

Prior to initiating any air injection, all MPs were purged until oxygen levels had stabilized, and initial oxygen, carbon dioxide, and TVH concentrations were sampled using portable gas analyzers, as described in the technical protocol document (Hinchee et al., 1992). At MP screened intervals MPA-15, MPB-24, MPC-15, and MPC-24, microorganisms had depleted soil gas oxygen supplies, indicating significant soil contamination. Table 3.1 summarizes the initial soil gas chemistry. Based on initial oxygen levels, it appears that there are both aerobic and anaerobic conditions beneath the site, and that air injection is required to more uniformly oxygenate these soils.

3.2 Air Permeability

An air permeability test was conducted according to protocol document procedures. Air was injected into VW-1 for 2.33 hours at a rate of approximately 62 scfm and an average pressure of 18 inches of water. The pressure response at each MP is shown in Table 3.2. The pressure measured at the MPs increased gradually during the period of air injection and reached maximum pressure within approximately 1 hour. Using the HyperVentilate® model, soil gas permeability values of between 21 and 45 darcys, typical for sandy soils, were calculated for this site. A radius of pressure influence of at least 30 feet was observed at the 15-, and 24-foot depths.

3.3 Oxygen Influence

The depth and radius of oxygen increase in the subsurface resulting from air injection into the central VW during pilot testing is the primary design parameter for full-scale bioventing systems. Optimization of full-scale and multiple VW

TABLE 3.1
INITIAL SOIL GAS CHEMISTRY
FORMER FIRE TRAINING AREA (FT-13)
KIRTLAND AFB, NEW MEXICO

MP	Depth (ft)	O_2 (%)	CO_2(%)	Field TVH (ppmv)	Lab TVH (ppmv)	TRPH (mg/kg)
VW	5-30	20.0	0.7	520	870	6,534
A	6	20.0	0.5	800	NS[a]	7,869
B	6	20.0	0.5	1,700	NS	1,338
C	6	10.0	4.5	5,000	NS	NS
D[b]	6	20.8	0.05	280	NS	NS
A	15	0.8	13.0	7,200	16,000	NS
B	15	10.0	5.0	6,000	NS	NS
C	15	1.5	12.5	7,000	NS	NS
D	15	20.2	0.4	260	NS	ND[c]
A	24	14.0	6.5	6,000	NS	NS
B	24	3.5	14.0	13,000	NS	NS
C	24	1.5	14.0	10,000	22,000	NS
D	21.5	20.0	0.6	600	NS	NS

a/ NS = not sampled
b/ Background well at Site FT-13
c/ ND = not detected

TABLE 3.2

PRESSURE RESPONSE DURING THE AIR PERMEABILITY TEST

FORMER FIRE TRAINING AREA (FT-13)

KIRTLAND AFB, NEW MEXICO

	Pressure Response (inches of water)								
	MPA			MPB			MPC		
Depth (ft)	6	15	24	6	15	24	6	15	24
Elapsed Time (min.)									
1.0	0.0	3.1	5.0	--[a/]	0.2	2.2	1.6	0.2	0.9
2.0	0.0	4.3	5.9	--	0.5	3.2	--	0.2	1.3
3.0	0.0	4.9	6.6	--	0.9	3.7	--	--	1.7
4.0	0.0	5.3	6.8	--	1.3	4.0	--	0.9	1.9
5.0	--	5.6	6.9	0.0	1.65	4.2	--	1.3	2.3
6.0	--	5.8	7.1	0.0	2.05	4.4	--	1.4	2.2
7.0	--	5.9	7.3	0.0	2.4	4.5	--	1.6	2.4
8.0	--	6.1	7.4	0.0	2.7	4.65	--	1.8	2.5
9.0	--	6.3	7.5	0.0	2.95	4.75	--	1.9	2.6
60	0.0	7.1	8.1	--	4.6	5.7	--	3.1	3.2
78	0.0	7.1	8.1	--	4.6	5.6	--	3.2	3.15
140	0.0	7.1	8.3	--	4.55	5.6	--	3.2	3.1

a/ -- denotes no reading taken at this time.

systems requires pilot testing to determine the volume of soil that can be oxygenated at a given flow rate and VW screen configuration.

Table 3.3 presents the change in soil gas oxygen levels that occurred during the 2.33-hour air injection test at the site. The air injection period at 62 scfm produced changes in soil gas oxygen levels at a distance of at least 30 feet from the central VW. Oxygen level increases were measured at MPA-15, MPA-24, MPB-24, MPC-6, and MPC-24. Oxygen level decreases were measured at MPA-6, MPB-6, MPB-15 and at MPC-15 due to movement of oxygen-depleted soil gas from areas of greater contamination.

Based on measured pressure response, which is an indicator of long-term oxygen transport, and changes in oxygen levels, it is anticipated that the radius of influence for a long-term bioventing system at this site will exceed 30 feet at all depths. Monitoring during the extended pilot test at this site will better define the effective treatment radius of VW-1.

3.4. In Situ Respiration Rates

The *in situ* respiration test was performed by injecting an approximate 3 percent mixture of helium in air (oxygen) into four MP screened intervals (MPA-15, MPB-24, MPC-15, and MPC-24) for an approximate 8-hour period. Oxygen loss and other changes in soil gas composition over time were then measured at these points. Oxygen, TVH, helium, and carbon dioxide were measured for a period of 56 hours following the initial measurement. The measured oxygen loss was then used to calculate the biological oxygen utilization rate. The results of *in situ* respiration testing at this site are presented in Figures 3.1 through 3.5. Table 3.4 provides a summary of the oxygen utilization rates.

Because of a loss of generator power, the injection of the helium/air mixture was interrupted sometime between 2200 hours on 8 April 1993 and 0700 hours on 9 April 1993. Because oxygen levels in all the MPs were above 19.5 percent, and the carbon dioxide levels were only 0.05 percent at 0800 on 9 April 1993, the initial slope of the respiration curve was not lost for any of the MPs. Therefore, ES believes the reported respiration rates are representative of shallow subsurface conditions at this site.

Because helium is a conservative, inert gas, the change in helium concentration over time can be useful in determining the effectiveness of the bentonite seals between MP screened intervals. Helium recovery was somewhat erratic, but because the observed helium loss was generally less than 75 percent of its initial concentration in the initial 1,000 minutes, and because helium will diffuse approximately three times faster than oxygen, the measured oxygen loss is assumed to be the result of bacterial respiration and not due to diffusion or faulty MP construction.

Results from this test indicate that MPA-15, MPB-24, MPC-15, and MPC-24 all had significant soil hydrocarbon contamination. Except for MPB-24, which had an initial oxygen concentration of 3.5 percent, all of these points had initial oxygen concentrations below 2 percent. The initial soil gas collected from MPB-24 had a

TABLE 3.3
INFLUENCE OF AIR INJECTION AT VENT WELL
ON MONITORING POINT OXYGEN LEVELS
FORMER FIRE TRAINING AREA (FT-13)
KIRTLAND AFB, NEW MEXICO

MP	Distance From VW (ft)	Depth(ft)	Initial O_2(%)	Final O_2(%)[a/]
A	10.0	6	20.0	18.2
A	10.0	15	0.8	9.5
A	10.0	24	14.0	20.5
B	20.0	6	20.0	7.6
B	20.0	15	10.0	0.8
B	20.0	24	3.5	20.0
C	30.0	6	10.0	11.0
C	30.0	15	1.5	0.0
C	30.0	24	1.5	3.0

a/ Duration of air injection=2.33 hours.

Figure 3.1
Respiration Test
Oxygen and Helium Concentrations
Site FT-13, VW-1
Kirtland AFB, NM

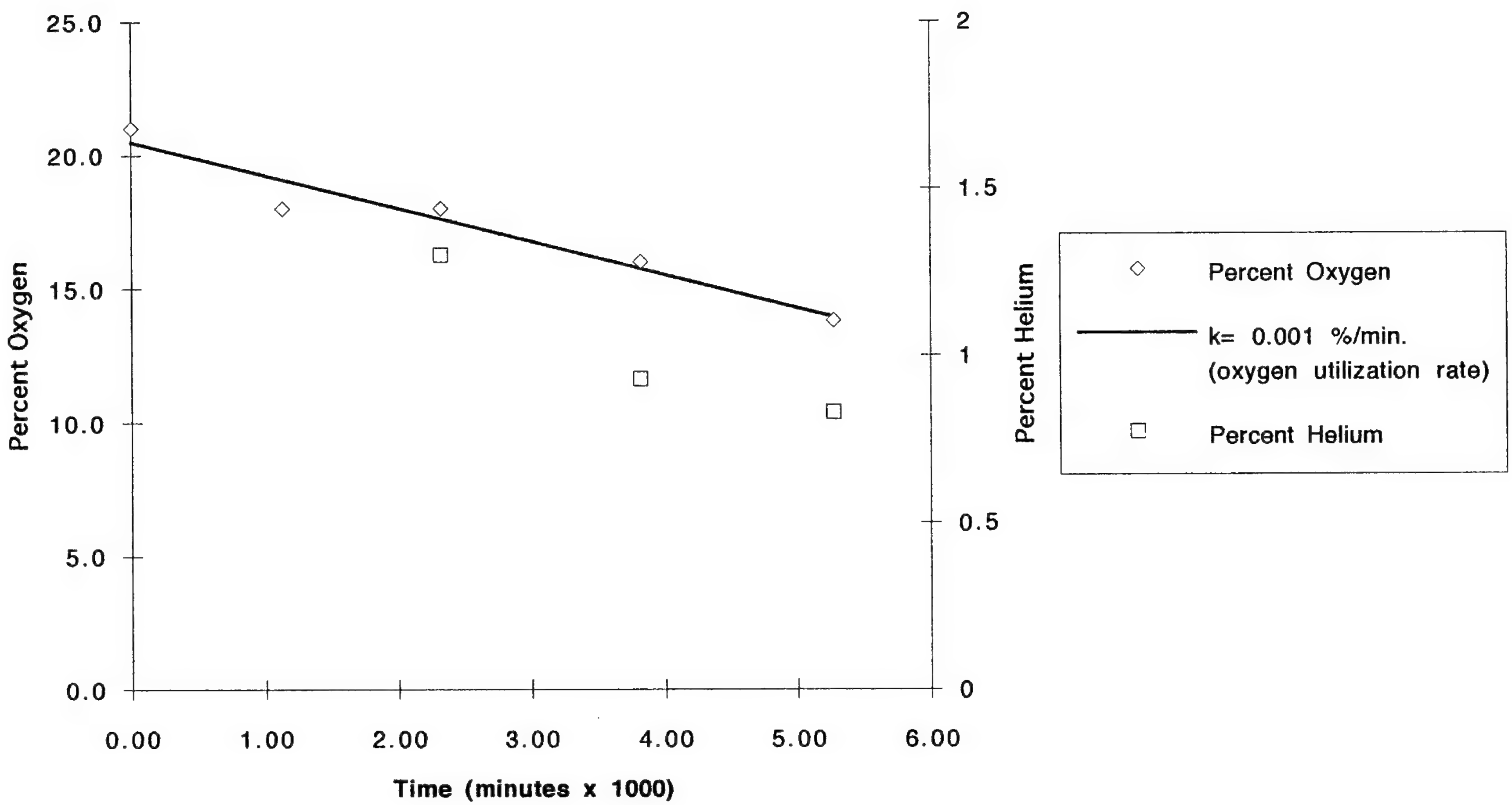


Figure 3.2
Respiration Test
Oxygen and Helium Concentrations
Site FT-13, MPA-15
Kirtland AFB, NM

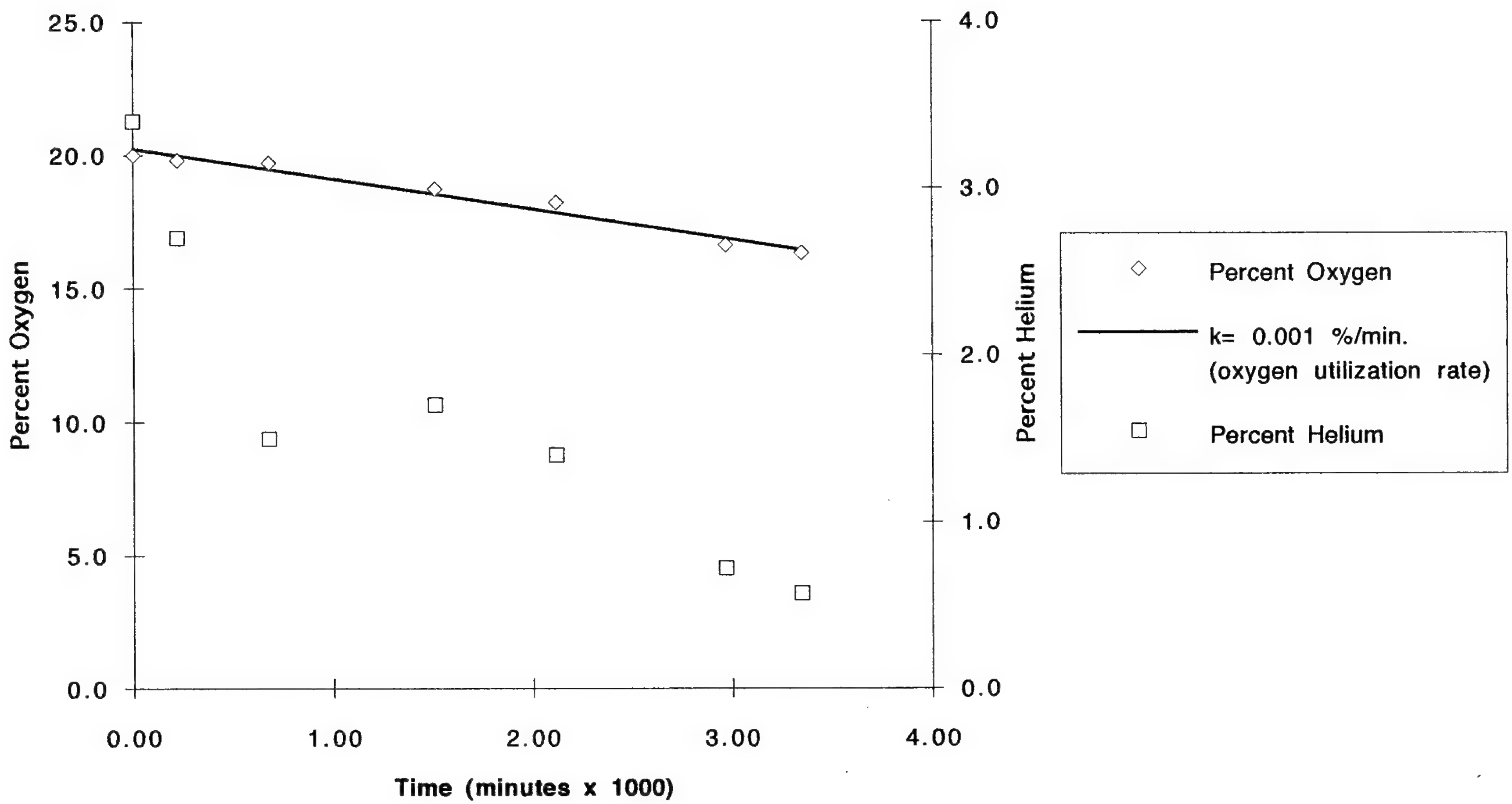


Figure 3.3
Respiration Test
Oxygen and Helium Concentrations
Site FT-13, MPB-24
Kirtland AFB, NM

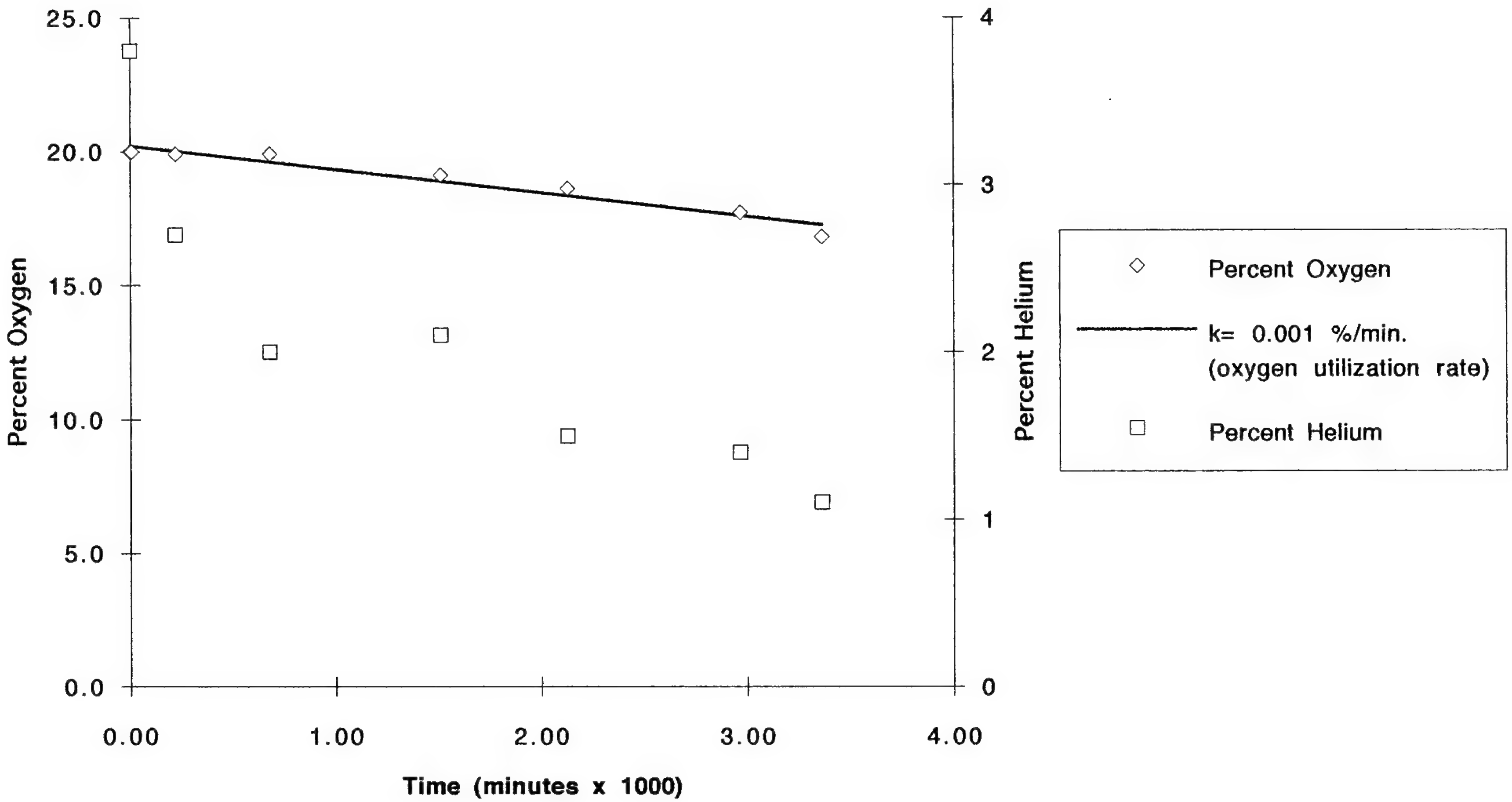


Figure 3.4
Respiration Test
Oxygen and Helium Concentrations
Site FT-13, MPC-15
Kirtland AFB, NM

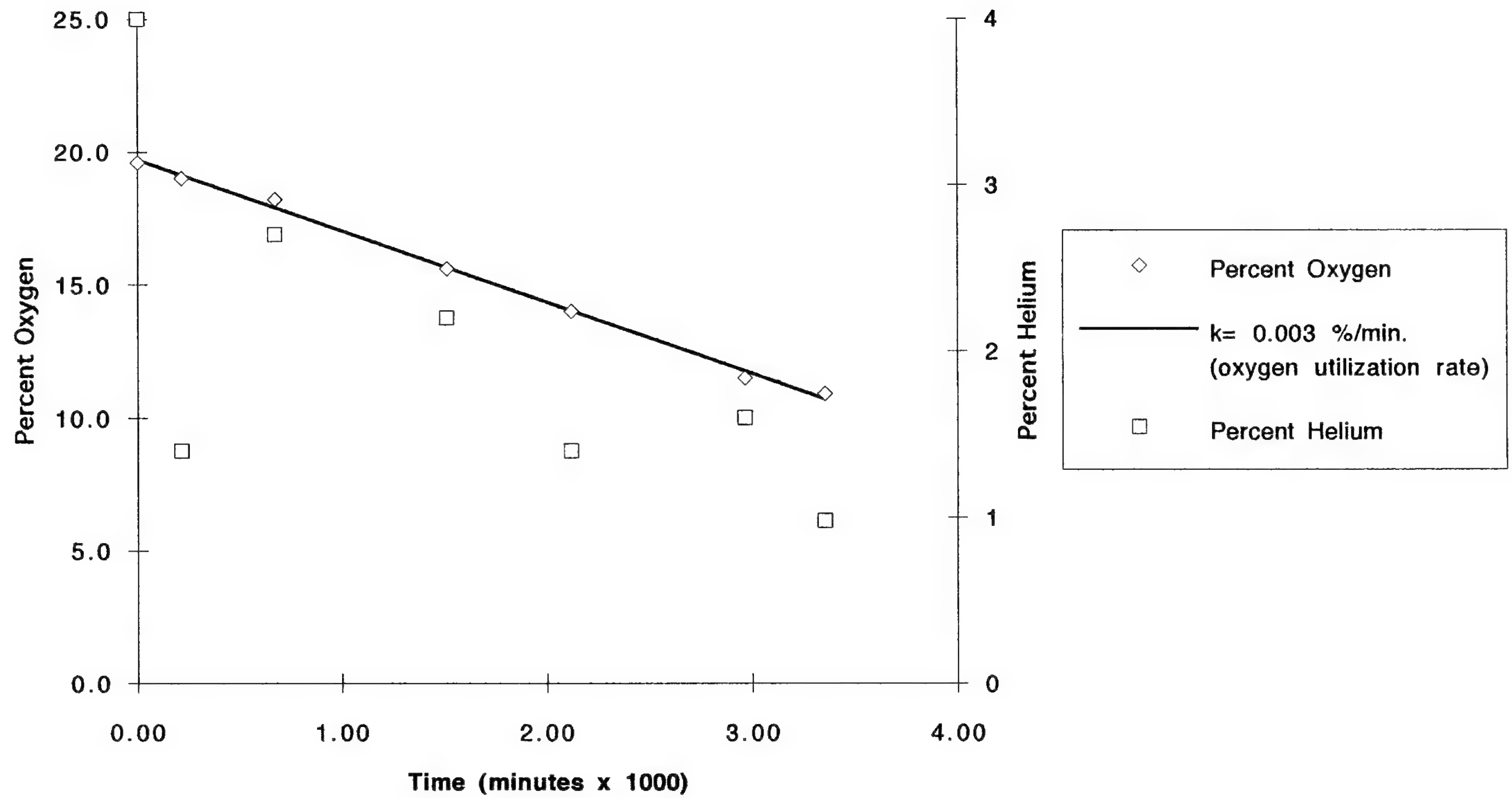


Figure 3.5
Respiration Test
Oxygen and Helium Concentrations
Site FT-13, MPC-24
Kirtland AFB, NM

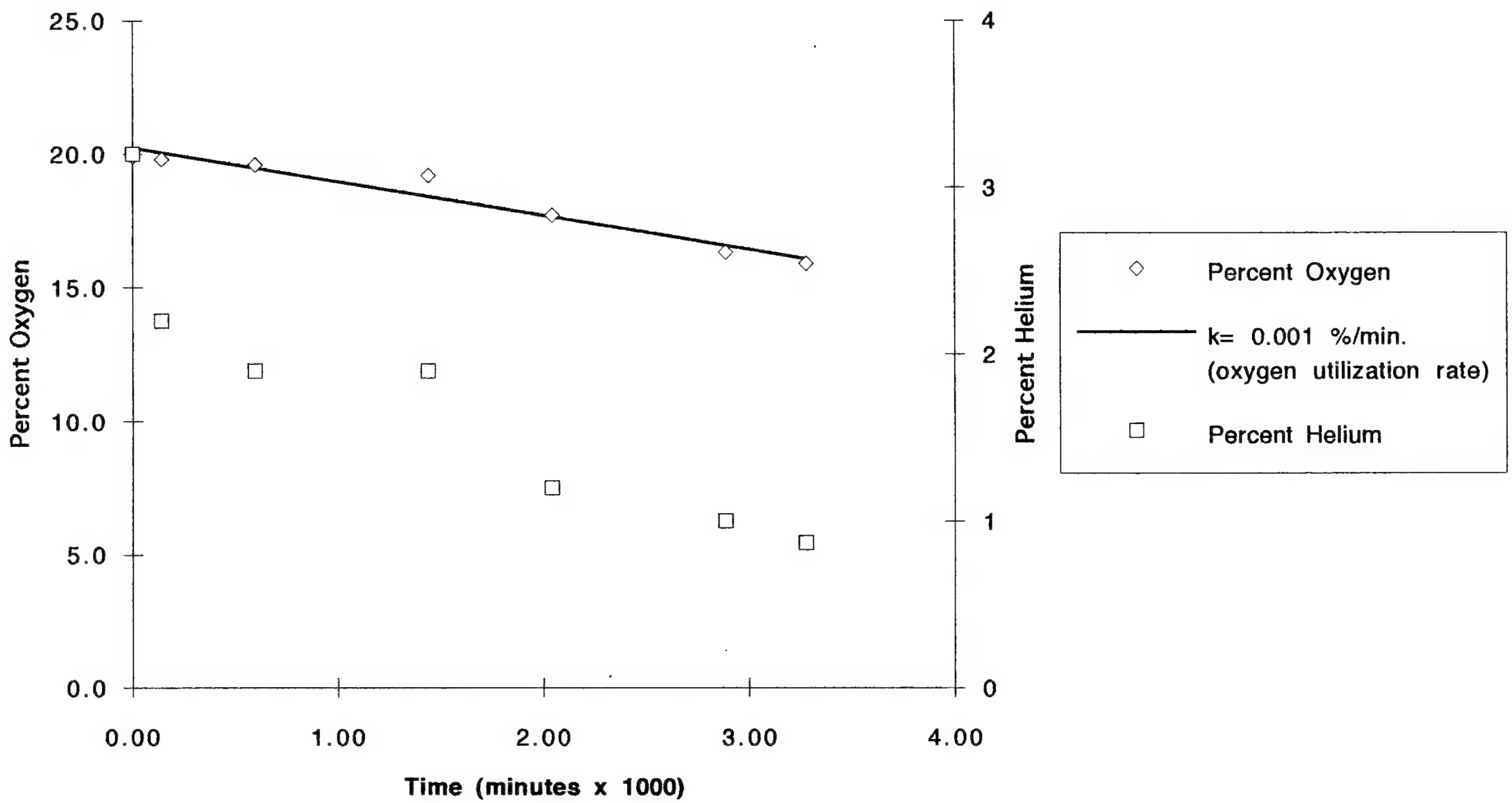


TABLE 3.4
OXYGEN UTILIZATION RATES
FORMER FIRE TRAINING AREA (FT-13)
KIRTLAND AFB, NEW MEXICO

MP	O_2 Loss [a/] (%)	Test Duration (min)	O_2 Utilization [a/] Rate (%/min)
VW	7.2	5270	0.0012
MPA-15	3.7	3360	0.0011
MPB-24	3.2	3360	0.0009
MPC-15	8.7	3360	0.0027
MPC-24	4.0	3280	0.0013

a/ Values based on linear regression (Figures 3.1 through 3.6).

TVH concentration of 13,000 part per million, volume per volume (ppmv) (Table 3.1). Oxygen loss during the respiration test occurred at slow rates, ranging from 0.0027 percent per minute at MPC-15 to 0.0009 percent per minute at MPB-24.

Based on these oxygen utilization rates, an estimated 246 to 690 milligrams (mg) of fuel per kilogram (kg) of soil can be degraded each year at this site. These estimates are based on an average air-filled porosity of approximately 0.24 liters per kg of soil, and a conservative ratio of 3.5 mg of oxygen consumed for every 1 mg of fuel biodegraded. Actual rates may exceed these estimates.

3.5 Potential Air Emissions

The long-term potential for VOC emissions from full-scale bioventing operations at this site is low because of the concrete cap; the relatively impermeable clayey soil overlying the shallow silts, sands, and gravels; and the low air injection rates. Emissions should be minimal because accumulated vapors will move slowly outward from the air injection point and will be biodegraded as they move horizontally through the soil. To confirm this, a GasTech® total hydrocarbon analyzer was used to monitor the breathing zone during the 2-hour air injection test. This health and safety monitoring of ambient air indicated no emissions of VOCs in excess of 1 ppmv.

4.0 RECOMMENDATIONS

4.1 Site FT-13

Initial bioventing tests at former Fire Training Area FT-13, Kirtland AFB, indicate that oxygen has been depleted in the contaminated soils, and that air injection is an effective method of increasing aerobic fuel biodegradation. AFCEE has recommended that air injection continue at this site to determine the long-term radius of oxygen influence and the effects of time, available nutrients, and changing temperatures on fuel biodegradation rates.

A small, 1-horsepower regenerative blower has been installed at the site to continue air injection at a rate of approximately 40 scfm. In July and October 1993 and January, 1994 ES will return to the site to sample and analyze the soil gas and conduct a repeat respiration test. In April 1994, a final respiration test will be conducted, and soil and soil gas samples will be collected from the site to determine the degree of remediation achieved during the first year of *in situ* treatment.

Based on the results of the first year of pilot-scale bioventing, AFCEE will recommend one of three options:

1. Upgrade, if necessary, and continue operation of the bioventing system for full-scale remediation of the site. AFCEE can assist the base in obtaining regulatory approval for upgrading and continued operation.
2. If final soil sampling indicates significant contaminant removal has occurred, AFCEE may recommend additional sampling to confirm that cleanup criteria have been achieved.

3. If significant difficulties or poor results are encountered during bioventing at this site, AFCEE may recommend removal of the blower system and proper abandonment of the VW and MPs.

4.2 Manzano Site FT-14

Installation of a pilot-scale bioventing system at the Manzano fire training area FT-14 should be deferred until further site characterization can be completed. Based on initial soil and soil gas sampling at this site, petroleum contamination appears to be limited to the near-surface soils at the western fire training pit. Soil gas oxygen levels in the upper eight feet of both pits were in excess of 2 percent, indicating that natural biodegradation is occurring without the enhancement of forced air injection.

5.0 REFERENCES

Hinchee, R.E., S.K. Ong., R.N. Miller, D.C. Downey, and Frandt. 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing.* Prepared for USAF Center for Environmental Excellence. May.

APPENDIX A
GEOLOGIC BORING LOGS, CHAIN-OF-CUSTODY FORMS, AND TEST DATA

GEOLOGIC BORING LOG

BORING NO.:	VW-1	CONTRACTOR:	Enviro Drill	DATE SPUD:	4/5/93
CLIENT:	AFCEE	RIG TYPE:	CME ~~75~~	DATE CMPL:	4/5/93
JOB NO.:	DE268.34.04	DRLG METHOD:	HSA	ELEVATION:	
LOCATION:	Kirtland AFB, NM	BORING DIA.:	THW ~~2.75~~ 10"	TEMP.:	70°F
GEOLOGIST:	THW	DRLG FLUID	N/A	WEATHER:	See comments

COMMENTS: partly cloudy and Fairly warm ≈ 70° F slight breeze

Elev. (ft.)	Depth (ft.)	Profile	USCS	Geologic Description	Sample No.	Sample Depth(ft)	Sample Type	Penet. Res.	Remarks TIP = Bkgrnd/Reading (ppm)
	0–1			concrete					
	2–4		CL	light brown, silty and sandy CLAY, strong HC odor, damp, black stringers of HC cont		2–4	SS	6 6 / 6 7	4200 ppm
	5–7		ML	Dark brown, ~~silt~~ clayey SILT, some sand to med.-grained, damp mod. HC odor		5–7		4 5 / 6 6	4500
	10–12			Light brown, very fine-grained to fine-grained clayey & silty SAND, damp, mod. HC odor		10–12		2 3 / 4 4	5400
	15–17		SM	Same as above, slightly coarser		15–17		4 4 / 4 4	6800 Sent to Lab
	20–22			Same as above, fine-grained sand, minor clay, weak HC odor		20–22		4 4 / 4 4	THW ~~6800~~ 2000
	25–27			Same as above to 26'		25–27		3 5 / 8 12	350
	26–28			light reddish brown, very poorly sorted silty & sandy GRAVEL, weak odor, damp, sharp contact					
	30–32		SM	light reddish brown, silty SAND, damp, no HC odor		30–~~32~~		8 11 / 12 12	20
	35								

BTEX TPH [illegible]

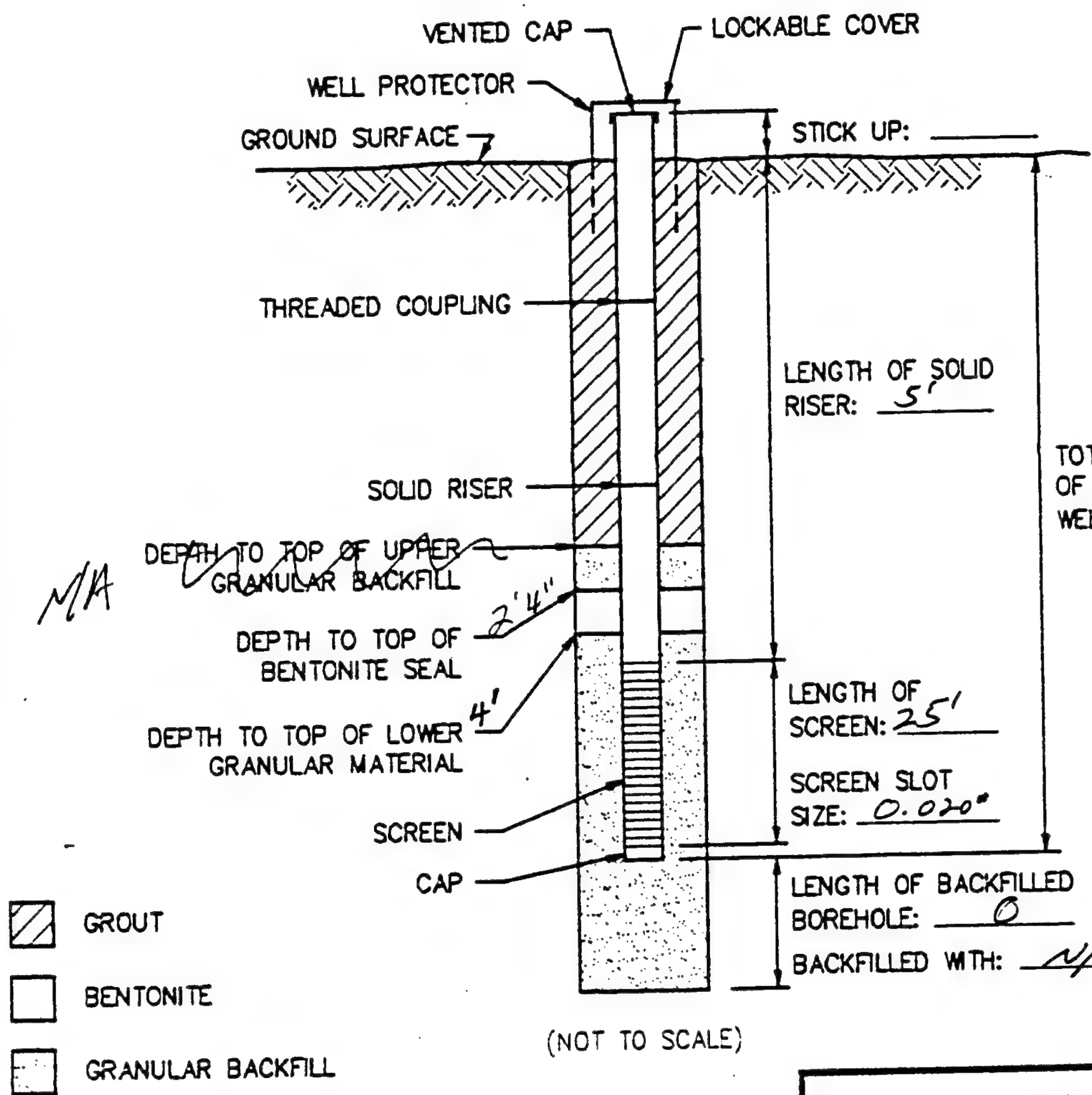
M[illegible]

TD @ 30'

sl - slight	v - very	f - fine	SAMPLE TYPE	
tr - trace	lt - light	m - medium	D - DRIVE	D Core recovery
sm - some	dk - dark	c - coarse	C - CORE	
& - and	bf - buff	BH - Bore Hole	G - GRAB	Core lost
@ - at	brn - brown	SAA - Same As Above		
w - with	blk - black	veg - Vegetation		Water level drilled

MONITORING WELL INSTALLATION RECORD

JOB NAME Kirtland AFB WELL NUMBER UW-1
JOB NUMBER DE268.34.04 INSTALLATION DATE 4/5/93 LOCATION
DATUM ELEVATION GROUND SURFACE ELEVATION
DATUM FOR WATER LEVEL MEASUREMENT
SCREEN DIAMETER & MATERIAL 4" ID sch 40 pvc SLOT SIZE 0.020"
RISER DIAMETER & MATERIAL 4" ID sch 40 pvc BOREHOLE DIAMETER 10"
GRANULAR BACKFILL MATERIAL 8-12 CO Silica Sand ES REPRESENTATIVE THW/RW
DRILLING METHOD HSA DRILLING CONTRACTOR Enviro drill



STABILIZED WATER LEVEL ______ FEET
BELOW DATUM.
MEASURED ON ______

FIGURE 2.4

EXAMPLE OF MONITORING WELL INSTALLATION RECORD

ENGINEERING-SCIENCE, INC.
Denver, Colorado

GEOLOGIC BORING LOG

BORING NO.: VMP-A
CLIENT: AFCEE
JOB NO.: DE268.34.04
LOCATION: Alb, Kirtland AFB, NM
GEOLOGIST: THW
COMMENTS:

CONTRACTOR:
RIG TYPE: CME 75
DRLG METHOD: HSA
BORING DIA.: 7.5"
DRLG FLUID: N/A

DATE SPUD: 4/5/93
DATE CMPL: 4/5/93
ELEVATION:
TEMP.: 70°F
WEATHER: Partly cloudy & windy

Elev. (ft.)	Depth (ft.)	Profile	USCS	Geologic Description	Sample No.	Sample Depth(ft)	Sample Type	Penet. Res.	Remarks TIP = Bkgrnd/Reading (ppm)
	1			Concrete					
			CL	Silty CLAY light gray, ~~clayey SILT~~ to clayey & silty fine-grained SAND, damp, very strong odor		2–4		5 5 5 7	Not enough sample sent to lab
	5			Light reddish brown, clayey & silty fine-grained sand, damp, strong odor		5–7		2 2 3 5	5,000
	10			Same as above		10–12		2 3 2 2	7200
	15		SM	Same as above less clay, slightly coarse sand; silty fine grained sand, strong odor, damp	15–17	15–17		7 8 → 11 10	3600
	20			light reddish brown, clayey & silty med to coarse-grained SAND very poorly sorted, damp, mod odor		20–22		4 4 4 5	3500
TD @ 25'?	25			Same as above	25–27	25–27		6 6 → 10 14	850
				Gravel layer @ 26' sharp contact light reddish brown silty & sandy GRAVEL, damp, weak odor					
	30								
	35								

sl - slight
tr - trace
sm - some
& - and
@ - at
w - with

v - very
lt - light
dk - dark
bf - buff
brn - brown
blk - black

f - fine
m - medium
c - coarse
BH - Bore Hole
SAA - Same As Above
veg - Vegetation

SAMPLE TYPE
D - DRIVE
C - CORE
G - GRAB

D Core recovery
Core lost
Water level drilled

Sheet 1 of

GEOLOGIC BORING LOG

BORING NO.:	VMP-B	CONTRACTOR:	Enviro driV	DATE SPUD:	4/6/93
CLIENT:	AFCEE	RIG TYPE:	CME 75	DATE CMPL:	4/6/93
JOB NO.:	DE268.34.04	DRLG METHOD:	HSA	ELEVATION:	
LOCATION:	Kirtland AFB	BORING DIA.:	7.5"	TEMP.:	45°F
GEOLOGIST:	TMW	DRLG FLUID	N/A	WEATHER:	cloudy, windy, cold scattered rain
COMMENTS:					

Elev. (ft.)	Depth (ft.)	Profile	USCS	Geologic Description	Sample No.	Sample Depth(ft)	Sample Type	Penet. Res.	Remarks TIP = Bkgrnd/Reading (ppm)
	1			concrete					
			CL	brown to light reddish brown, SILTY CLAY, damp, strong HC odor, contains some med sand grains, Patches of Black HC Staining		2-4			3900
	5			light reddish brown, silty fine-grained ~~very~~ poorly sorted SAND, some very coarse sand fragments, damp strong HC odor		5-7		6 7 7 8	5200 5-7' sample to lab
	10		SM	light reddish brown SILTY, fine-grained, very poorly sorted SAND, some very coarse sand frags, damp, strong HC odor		10-12		~~7~~ 7 7 8	5200 ~~Sample to lab~~ 18" of Recovery Not enough sample for lab
	15			Same as above		15-17		6 7 10 12	4000
	20			Same as above		20-22		6 7 8 10	6600
	25			Same as above becoming coarser					
	25.5			light reddish brown, very poorly sorted, silty & sandy GRAVEL, damp, weak to mod petroleum odor				6 8 10 12	5200
	30								
	35								

sl - slight	v - very	f - fine	SAMPLE TYPE	
tr - trace	lt - light	m - medium	D - DRIVE	D Core recovery
sm - some	dk - dark	c - coarse	C - CORE	
& - and	bf - buff	BH - Bore Hole	G - GRAB	Core lost
@ - at	brn - brown	SAA - Same As Above		
w - with	blk - black	veg - Vegetation		Water level drilled

GEOLOGIC BORING LOG

BORING NO.:	VMP-C	CONTRACTOR:	Enviro-drill	DATE SPUD:	4/6/93
CLIENT:	AFCEE	RIG TYPE:	CME 75	DATE CMPL:	4/6/93
JOB NO.:	DE268.34	DRLG METHOD:	HSA	ELEVATION:	
LOCATION:	Kirtland AFB	BORING DIA.:	7.5"	TEMP.:	
GEOLOGIST:	THW	DRLG FLUID	N/A	WEATHER:	cloudy, cold & windy

COMMENTS:

Elev. (ft.)	Depth (ft.)	Profile	USCS	Geologic Description	Sample No.	Sample Depth(ft)	Sample Type	Penet. Res.	Remarks TIP = Bkgrnd/Reading (ppm)
	1			concrete					
			CL	light brown, silty & sandy cohesive CLAY, slightly damp, strong petroleum odor		2 – 4'		3 4 5 6	2000
	5			Same as above to 6' light brown to dark brown silty & sandy CLAY, some very coarse sand grains, damp, strong HC odor, becomes SILT near base		5 – 7		2 5 6 8	2400
sharp contact @ 10.25'	10			Black HC staining throughout (Patchy)		10 – 12		2 3 2 5	Sent to lab. Not enough sample for headspace
				Reddish brown clayey and sandy SILT to fine-grained sand some very coarse sand grains, damp, petroleum odor					
	15		SM	Same as above, SILT to very fine-grained sand		15 – 17		5 8 10 12	450
	20			Same as above weak HC odor		20 – 22		4 6 6 7	600
@ 26'	25					25 – 27		5 8 8 11	400
25.75				light reddish brown, very poorly sorted silty and sandy GRAVEL damp, moderate HC odor					
	30			Sharp contact back into reddish brown clayey and sandy silt to very fine grained sand, mod. HC odor, damp					
	35								

sl - slight	v - very	f - fine	
tr - trace	lt - light	m - medium	
sm - some	dk - dark	c - coarse	
& - and	bf - buff	BH - Bore Hole	
@ - at	brn - brown	SAA - Same As Above	
w - with	blk - black	veg - Vegetation	

SAMPLE TYPE
- D - DRIVE
- C - CORE
- G - GRAB

D Core recovery

Core lost

Water level drilled

GEOLOGIC BORING LOG

BORING NO.:	VMP-D	CONTRACTOR:	Enviro drill	DATE SPUD:	4/6/93
CLIENT:	AFCEE	RIG TYPE:	CME 75	DATE CMPL:	4/6/93
JOB NO.:	DE268.34.04	DRLG METHOD:	HSA	ELEVATION:	
LOCATION:	Kirtland AFB, FT-14	BORING DIA.:	7.5"	TEMP.:	65°F
GEOLOGIST:	THW	DRLG FLUID	N/A	WEATHER:	Cloudy & Cool Very Windy
COMMENTS:					

Elev. (ft.)	Depth (ft.)	Profile	USCS	Geologic Description	Sample No.	Sample Depth(ft)	Sample Type	Penet. Res.	Remarks TIP = Bkgrnd/Reading (ppm)
	1		CL	Light Brown, Silty & sandy CLAY, roots, damp, No odor					
	5					5		4 4	120*
			ML	Same as above Grades into Reddish brown clayey and sandy SILT damp, no odor		7		5 5	
	10			Reddish brown clayey and sandy SILT to Fine grained SAND, some very ~~tar~~ coarse sand grains (to Gravel), damp, No odor		10		4 4	80
						12		5 6	
	15		SM	Same as above		15		5 7	Sent to lab
						17		8 5	
	20			Same as above		20			170
						22			
TD @ 25'	25			Same as above ~~TD @ 2~~		25			90
						27			
	30								
	35								

* HC meter on methane response yes, probe reading methane or similar

sl - slight	v - very	f - fine	**SAMPLE TYPE**	
tr - trace	lt - light	m - medium	D - DRIVE	D Core recovery
sm - some	dk - dark	c - coarse	C - CORE	
& - and	bf - buff	BH - Bore Hole	G - GRAB	Core lost
@ - at	brn - brown	SAA - Same As Above		
w - with	blk - black	veg - Vegetation		Water level drilled

GEOLOGIC BORING LOG

Manzano Sill

BORING NO.:	VW-2	CONTRACTOR:	Enviro drill	DATE SPUD:	4/6/93
CLIENT:	AFCEE	RIG TYPE:	CME 75	DATE CMPL:	4/6/93
JOB NO.:	DE 268.34	DRLG METHOD:	HSA	ELEVATION:	
LOCATION:	Manzano-KL AFB	BORING DIA.:	7.5"	TEMP.:	55°F
GEOLOGIST:	THW	DRLG FLUID	N/A	WEATHER:	Ptly Cloudy & Wi[ndy] cool
COMMENTS:					

Elev. (ft.)	Depth (ft.)	Profile	USCS	Geologic Description	Sample No.	Sample Depth(ft)	Sample Type	Penet. Res.	Remarks TIP = Bkgrnd/Reading (ppm)
	1			~~First 6" is very oily - black~~					
				First 6" is very oily - black sludge. Dark brown clayey, silty & sandy Gravel, damp, st. Fuel oil scent	2–4		~~2~~ / ~~2~~	22 / 21	Direct sample, sent to lab
	5		GM	No recovery for sample from 5 to 7'					
	10			Brown, clayey, silty & sandy GRAVEL, strong petroleum odor, damp, lots of clay	10–12			4 5 / 5 7	220
	15		CL	Brown Silty, sandy & Gravelly CLAY, moderate petroleum odor, damp				5 8 / 7 10	185
	20		GM	clayey, silty & sandy GRAVEL, damp, mod. petroleum odor				7 9 / 12 16	160
			ML	light reddish brown, sandy and gravelly silt, damp, very weak odor					
	25			Reddish Brown Silt clayey & Sandy Silt, damp, No odor		2		9 8 / 12 16	80
TD @ 28'									
	30								
	35								

sl - slight	v - very	f - fine	**SAMPLE TYPE**
tr - trace	lt - light	m - medium	D - DRIVE — D Core recovery
sm - some	dk - dark	c - coarse	C - CORE
& - and	bf - buff	BH - Bore Hole	G - GRAB — Core lost
@ - at	brn - brown	SAA - Same As Above	
w - with	blk - black	veg - Vegetation	Water level drilled

MONITORING WELL INSTALLATION RECORD

JOB NAME Kirtland AFB WELL NUMBER VW-2

JOB NUMBER DE268.34.04 INSTALLATION DATE 4/6/93 LOCATION ______

DATUM ELEVATION ______ GROUND SURFACE ELEVATION ______

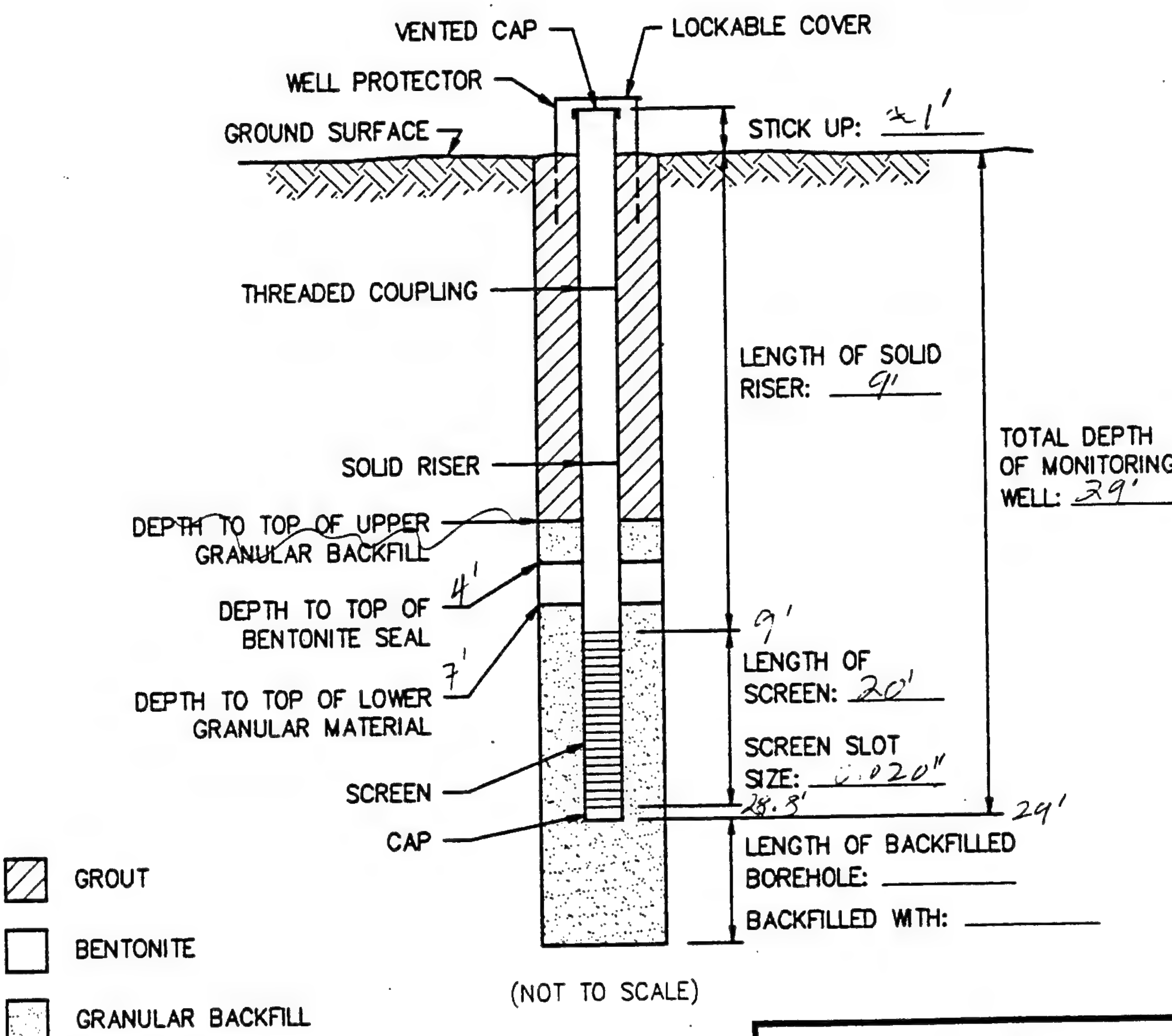
DATUM FOR WATER LEVEL MEASUREMENT ______

SCREEN DIAMETER & MATERIAL 4" Sch 40 PVC SLOT SIZE 0.020"

RISER DIAMETER & MATERIAL 4" Sch 40 PVC BOREHOLE DIAMETER 10"

GRANULAR BACKFILL MATERIAL 8-12 CO Silica Sand ES REPRESENTATIVE TRW

DRILLING METHOD HSA DRILLING CONTRACTOR Enviro Drill



STABILIZED WATER LEVEL ______ FEET BELOW DATUM.
MEASURED ON ______

FIGURE 2.4

EXAMPLE OF MONITORING WELL INSTALLATION RECORD

ENGINEERING-SCIENCE, INC.
Denver, Colorado

CHAIN OF CUSTODY RECORD

Page ____ of ____

ENGINEERING-SCIENCE, INC.
1700 BROADWAY, SUITE 900
DENVER, COLORADO 80290
303-831-8100

ES Job No.
DE268.3 4 .08

AFCEE BIOVENTING PILOT TESTS

Base: Kirtland AFB

Site: ~~FT-14~~ FT-13 thru

Sampler(s): (Signature) Todd Wiedemeier

Ship To:

AIR TOXICS LTD.
11325 Sunrise Gold Circle, Suite 4
Rancho Cordova, CA 95742

Attn: Bob Freeman
(916) 638-9892

Preservative: NONE

Analysis Required

Date	Time	Sample Description	Lab I.D.	No. of Contrs.	TO-3(EPA)	(BTEX & TPH)	Sample Type	Matrix	Remarks
4/7/93	1046	KL-VW-1		1	X	X	G C	AIR	
4/7/93	1150	KL-VMP-A-15		1	X	X	G C	AIR	
4/7/	1145	KL-VMP-C-24		1	X	X	G C	AIR	
							G C	AIR	
							G C	AIR	
							G C	AIR	
							G C	AIR	
							G C	AIR	
							G C	AIR	
							G C	AIR	
							G C	AIR	
							G C	AIR	
							G C	AIR	
							G C	AIR	
							G C	AIR	
							G C	AIR	

Relinquished by: (Signature)	Date / Time	Recieved for Laboratory by: (Signature)	Date / Time
Todd Wiedemeier	4/7/93 5:45		
Relinquished by: (Signature)	Date / Time	Recieved for Laboratory by: (Signature)	Date / Time

Remarks:

G - Grab Sample, C - Composite Sample

Distribution: Original Accompanies Shipment. Copies to: Coordinator Field Files

Federal Express Number: ____________

Airbill Number: ____________

ENGINEERING-SCIENCE, INC.
1700 Broadway, Suite 900 • Denver, Colorado
(303) 831-8100

CCRAIR

CHAIN OF CUSTODY RECORD

Page ___ of ___

ENGINEERING-SCIENCE, INC.
1700 BROADWAY, SUITE 900
DENVER, COLORADO 80290
303-831-8100

ES Job No.
DE268.34 ___.08

AFCEE BIOVENTING PILOT TESTS

Base: Kirtland

Site: ~~FT-14 ~~+3 mat~~ Manzano~~
FT-13 and Manzano

Sampler(s): (Signature)

Preservative: NONE | HOLD | AT 4C | NONE

Analysis Required

Ship To:

ENGINEERING-SCIENCE LABORATORY
600 Bancroft Way
Berkeley, CA 94710

Attn: Tom Paulson
(510) 841-7353

Date	Time	Sample Description	Lab I.D.	No. of Contrs.	SW 9045 (PH)	A 403 (ALKA)	SW 7380 (IRON)	SW 846 (MOIST)	SW 8020 (BTEX)	E 418.1 (TRPH)	E 351.2 (TKN)	E 365.3 (PHOS)	UCM (CLASS)	Sample Type	Matrix	Remarks
4/5/93		KL-VW-15-17		2			1		1			0		G C	SOIL	
4/6/93		KL-VMPC-10-12		3			1		1		1			G C	SOIL	
4/6		KL-VMPD-15-17		3			1		1		1			G C	SOIL	
4/6		KL-VMPB-5-7		3			1		1		1			G C	SOIL	
4/6		KL-VW2-2-4		3			1		1		1			G C	SOIL	
4/5		KL-VMPA-2-4		3			1		1		1			G C	SOIL	
			THU	3			1		1		1			G C	SOIL	
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Relinquished by: (Signature)	Date / Time	Recieved for Laboratory by: (Signature)	Date / Time
	4/7/93		
Relinquished by: (Signature)	Date / Time	Recieved for Laboratory by: (Signature)	Date / Time

Remarks:

G - Grab Sample, C - Composite Sample

Distribution: Original Accompanies Shipment. Copies to: Coordinator Field Files

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CCRSOIL

Kirtland AFB Site FT−13
Biodegradation Rate Calculations

enter data	calculated data

Formula: $K_b = K_o \times 1/100\% \times A \times D_o \times C$ Where:

K_b = fuel biodegradation rate

K_o = O_2 utilization rate (%/min.)

A = volume of air/kg soil

D_o = O_2 density 1340 mg/L

C = Carbon/O_2 ratio for hexane mineralization = 1/3.5

Test Results: MPA−15

K_o = max. observed rate 0.0011 %/min.

w = moisture content 7 %

Assume: Soil properties for Mixed−grained sand Specify from Table 1.4 (Ref. Foundation Engineering, Peck, Hanson, and Thornburn, John Wiley Press, 1974)

Porosity:	$n =$	0.35
Unit weight (dry):	$^{g}d =$	1.67
Void ratio:	$e = n/1-n =$	0.54
Specific gravity:	G =	2.65

Calculate A = Air filled volume (V_a)/unit wt.

Solving for 1 liter of soil

a) $V_v = n * 1$ L

$V_v =$ 0.35 liters V_v = void volume

b) $S_r = Gw/e$

$S_r =$ 0.34 S_r = degree of saturation

c) $V_w = S_r \times V_v$

$V_w =$ 0.12 liters V_w = volume of water

d) $V_a = V_v - V_{vw}$

$V_a =$ 0.23 liters V_w = volume of water

e) Bulk density = $^{g}d + (V_w \times {}^{g}w)$ = 1.8 kg/l soil

f) A = V_a/Bulk density = 0.128 l air/kg soil

$K_b = K_o \times 1/100\% \times A \times D_o \times C \times$ 525,600 min/yr = 294 mg TPH/year

afcee1/klmpa15.wk1/06−08−93

Kirtland AFB Site FT−13
Biodegradation Rate Calculations

enter data	calculated data

Formula: $K_b = K_o \times 1/100\% \times A \times D_o \times C$ Where:

K_b = fuel biodegradation rate

K_o = O_2 utilization rate (%/min.)

A = volume of air/kg soil

D_o = O_2 density 1340 mg/L

C = Carbon/O_2 ratio for hexane mineralization = 1/3.5

Test Results: MPB−24 K_o = max. observed rate 0.0009 %/min.
w = moisture content 6 %

Assume: Soil properties for Mixed−grained sand Specify from Table 1.4 (Ref. Foundation Engineering, Peck, Hanson, and Thornburn, John Wiley Press, 1974)

Porosity:	n =	0.35
Unit weight (dry):	$^g d$ =	1.67
Void ratio:	$e = n/1-n$ =	0.54
Specific gravity:	G =	2.65

Calculate A = Air filled volume (V_a)/unit wt.
Solving for 1 liter of soil

a) $V_v = n * 1\ L$
V_v = 0.35 liters V_v = void volume

b) $S_r = Gw/e$
S_r = 0.29 S_r = degree of saturation

c) $V_w = S_r \times V_v$
V_w = 0.1 liters V_w = volume of water

d) $V_a = V_v - V_{vw}$
V_a = 0.25 liters V_w = volume of water

e) Bulk density = $^g d + (V_w \times {^g w})$ = 1.8 kg/l soil

f) A = V_a/Bulk density = 0.139 l air/kg soil

$K_b = K_o \times 1/100\% \times A \times D_o \times C \times$ 525,600 min/yr = 246 mg TPH/year

afcee1/klvmpb24.wk1/06−08−93

Kirtland AFB Site FT−13
Biodegradation Rate Calculations

enter data	calculated data

Formula: $K_b = K_o \times 1/100\% \times A \times D_o \times C$ Where:

K_b = fuel biodegradation rate

K_o = O_2 utilization rate (%/min.)

A = volume of air/kg soil

D_o = O_2 density 1340 mg/L

C = Carbon/O_2 ratio for hexane mineralization = 1/3.5

Test Results: MPC−15

K_o =	max. observed rate	0.0027	%/min.
w =	moisture content	7	%

Assume: Soil properties for Mixed−grained sand Specify from Table 1.4 (Ref. Foundation Engineering, Peck, Hanson, and Thornburn, John Wiley Press, 1974)

Porosity:	n =	0.35
Unit weight (dry):	^gd =	1.67
Void ratio:	$e = n/1-n$ =	0.54
Specific gravity:	G =	2.65

Calculate A = Air filled volume (V_a)/unit wt.

Solving for 1 liter of soil

a) $V_v = n * 1$ L

V_v = 0.35 liters V_v = void volume

b) $S_r = Gw/e$

S_r = 0.34 S_r = degree of saturation

c) $V_w = S_r \times V_v$

V_w = 0.12 liters V_w = volume of water

d) $V_a = V_v - V_{vw}$

V_a = 0.23 liters V_w = volume of water

e) Bulk density = $^gd + (V_w \times {}^gw)$ = 1.8 kg/l soil

f) A = V_a/Bulk density = 0.128 l air/kg soil

$K_b = K_o \times 1/100\% \times A \times D_o \times C \times$ 525,600 min/yr = 690 mg TPH/year

Kirtland AFB Site FT−13
Biodegradation Rate Calculations

enter data	calculated data

Formula: $K_b = K_o \times 1/100\% \times A \times D_o \times C$ Where:

K_b = fuel biodegradation rate

K_o = O_2 utilization rate (%/min.)

A = volume of air/kg soil

D_o = O_2 density 1340 mg/L

C = Carbon/O_2 ratio for hexane mineralization = 1/3.5

Test Results: MPC−24

K_o = max. observed rate 0.0013 %/min.

w = moisture content 6 %

Assume: Soil properties for Mixed−grained sand Specify from Table 1.4 (Ref. Foundation Engineering, Peck, Hanson, and Thornburn, John Wiley Press, 1974)

Porosity:	$n =$	0.35
Unit weight (dry):	$\gamma d =$	1.67
Void ratio:	$e = n/1-n =$	0.54
Specific gravity:	G =	2.65

Calculate A = Air filled volume (V_a)/unit wt.

Solving for 1 liter of soil

a) $V_v = n * 1$ L

V_v = 0.35 liters V_v = void volume

b) $S_r = Gw/e$

S_r = 0.29 S_r = degree of saturation

c) $V_w = S_r \times V_v$

V_w = 0.1 liters V_w = volume of water

d) $V_a = V_v - V_{vw}$

V_a = 0.25 liters V_w = volume of water

e) Bulk density = $\gamma d + (V_w \times \gamma w)$ = 1.8 kg/l soil

f) A = V_a/Bulk density = 0.139 l air/kg soil

$K_b = K_o \times 1/100\% \times A \times D_o \times C \times$ 525,600 min/yr = 355 mg TPH/year

afcee1/klvmpc24.wk1/06−08−93

Air Permeability Test - Data Analysis (cont.)

(1) Enter radial distances of monitoring points → r= 20 (ft) r= 20 (ft) r= (ft)

(2) Enter measured times and gauge vacuums →

(min)	(in H2O)	(min)	(in H2O)	(min)	(in H2O)
0	.2	0	0		
1	.2	1	2.2		
2	.5	2	3.2		
3	.9	3	3.7		
4	1.3	4	4		
5	1.65	5	4.2		
6	2.05	6	4.4		
7	2.4	7	4.5		
8	2.7	8	4.65		
9	2.95	9	4.75		

clear clear clear

(3) Enter (optional):

a) flowrate 62 (SCFM)

b) screened interval thickness 20 (ft)

-->Calculate<--

k= 21.7488 darcy (A)	k= 35.0639 darcy (A)	k= darcy (A)
k= 13.9147 darcy (B)	k= 493.897 darcy (B)	k= darcy (B)

Return Explanation & Statistics AP8

Air Permeability Test - Data Analysis (cont.)

(1) Enter radial distances of monitoring points → r= 30 (ft) | r= 30 (ft) | r= (ft)

(2) Enter measured times and gauge vacuums →

(min)	(in H2O)	(min)	(in H2O)	(min)	(in H2O)
0	.1	0	0		
0.5	0.2	0.5	0.9		
2	0.2	2	1.3		
4	0.9	3	1.7		
5	1.3	4	1.9		
6	1.4	5	2.3		
7	1.6	6	2.2		
8	1.8	7	2.4		
9	1.9	8	2.5		
10	1.9	9	2.6		

clear | clear | clear

(3) Enter (optional):

a) flowrate 62 (SCFM)

b) screened interval thickness 20 (ft)

-->Calculate<--

k= 42.4598 darcy (A)	k= 45.1674 darcy (A)	k= darcy (A)
k= 53.5341 darcy (B)	k= 221.061 darcy (B)	k= darcy (B)

Return | Explanation & Statistics | AP8

Air Permeability Test - Data Analysis (cont.)

① Enter radial distances of monitoring points → r= 10 (ft) r= 10 (ft) r= (ft)

② Enter measured times and gauge vacuums →

(min)	(in H2O)	(min)	(in H2O)	(min)	(in H2O)
0	0	0	0		
1	3.1	1	5.0		
2	4.3	2	5.9		
3	4.9	3	6.6		
4	5.3	4	6.8		
5	5.6	5	6.9		
6	5.8	6	7.1		
7	5.9	7	7.3		
8	6.1	8	7.4		
9	6.3	9	7.5		

clear clear clear

③ Enter (optional):

a) flowrate

62 (SCFM)

b) screened interval thickness

20 (ft)

-->Calculate<--

k= 26.8690 darcy (A) k= 32.7949 darcy (A) k= darcy (A)

k= 133.933 darcy (B) k= 2232.96 darcy (B) k= darcy (B)

Return Explanation & Statistics AP8

Respiration Test
Kirtland AFB, NM

Monitoring Point	Date	Days Elapsed (frac. days)	Time	Hrs elapsed (fractional days)	Days Elapsed	Elapsed Time (min. x 1000)	O2%	CO2%	Total Hydro-carbon	Helium	Comments	Trend of O2 Time	New x-values	k
VW-1	04/07/93	0.00	17:57	0.00	0.00	0.00	21.0	0.5	NA	NA		20.465605	0	0.00124
VW-1	04/08/93	1.00	12:50	-0.21	0.79	1.13	18.0	0.6	520	NA		13.939351	5.27	
VW-1	04/09/93	2.00	08:35	-0.39	1.61	2.32	18.0	0.6	1880	1.3	2nd He reading 1.2			
VW-1	04/10/93	3.00	09:37	-0.35	2.65	3.82	16.0	0.8	1140	0.93	2nd He reading .83 Purged 5 min.			
VW-1	04/11/93	4.00	09:45	-0.34	3.66	5.27	13.8	1.4	1320	0.83	2nd He reading .92 Purged 5 min.			
MPA-15	04/09/93	0.00	08:00	0.00	0.00	0.00	20.0	0.05	300	3.4		20.230816	0	0.00114
MPA-15	04/09/93	0.00	11:40	0.15	0.15	0.22	19.8	0.15	440	2.7	2nd/3d He readings 2.8,3.1	16.426866	3.35	
MPA-15	04/09/93	0.00	19:18	0.47	0.47	0.68	19.7	0.2	380	1.5	2nd He reading 1.3			
MPA-15	04/10/93	1.00	09:10	0.05	1.05	1.51	18.7	0.1	500	1.7	2nd He reading 2.0			
MPA-15	04/10/93	1.00	19:18	0.47	1.47	2.12	18.2	0.2	520	1.4	2nd He reading 1.2			
MPA-15	04/11/93	2.00	09:30	0.06	2.06	2.97	16.6	0.2	500	0.72	2nd He reading .52			
MPA-15	04/11/93	2.00	15:50	0.33	2.33	3.35	16.3	0.3	600	0.57	2nd He reading .73 Begin blower injection here			
MPA-15	04/12/93	3.00	08:35	0.02	3.02	4.36	20.6	0.5	1000	0				
												Trend of	New	k
MPA-24	04/07/93	0.00	17:07	0.00	0.00	0.00	20.5	0.5	2400	NA		O2/Time	x-values	0.00058
MPA-24	04/09/93	2.00	08:25	-0.36	1.64	2.36	20.0	0.7	200	2.2		20.819446	0	
MPA-24	04/11/93	4.00	15:56	-0.05	3.95	5.69	17.3	1.5	400	0.99	2nd He reading .90 Begin blower injection here	17.525555	5.69	
MPB-24	04/09/93	0.00	08:05	0.00	0.00	0.00	20.0	0.05	760	3.8		Trend of	New	k
MPB-24	04/09/93	0.00	08:10	0.00	0.00	0.00	20.0	0.05	720	NA	Resample - 2 min purge	O2/Time	x-values	0.00088
MPB-24	04/09/93	0.00	11:45	0.15	0.15	0.22	19.9	0.2	1440	2.7	2nd He reading 3.1	20.196518	0	
MPB-24	04/09/93	0.00	19:24	0.47	0.47	0.68	19.9	0.2	1840	2	2nd He reading 2.4	17.237151	3.36	
MPB-24	04/10/93	1.00	09:15	0.05	1.05	1.51	19.1	0.25	2000	2.1	2nd He reading 1.9			
MPB-24	04/10/93	1.00	19:32	0.48	1.48	2.13	18.6	0.4	2400	1.5	2nd He reading 1.4			
MPB-24	04/11/93	2.00	09:32	0.06	2.06	2.97	17.7	0.8	2800	1.4	2nd He reading 1.3			
MPB-24	04/11/93	2.00	16:05	0.33	2.33	3.36	16.8	1.6	3600	1.1	2nd He reading .98			
MPC-15	04/09/93	0.00	08:15	0.00	0.00	0.00	19.6	0.05	196	4		Trend of	New	k
MPC-15	04/09/93	0.00	11:50	0.15	0.15	0.22	19.0	0.2	196	1.4	2nd He reading 1.4	O2/Time	x-values	0.00268
MPC-15	04/09/93	0.00	19:30	0.47	0.47	0.68	18.2	0.3	320	2.7	2nd He reading 2.1	19.691229	0	
MPC-15	04/10/93	1.00	09:30	0.05	1.05	1.52	15.6	0.1	300	2.2	2nd He reading 1.9	10.692824	3.36	
MPC-15	04/10/93	1.00	19:35	0.47	1.47	2.12	14.0	0.2	400	1.4	2nd He reading 1.5			
MPC-15	04/11/93	2.00	09:38	0.06	2.06	2.96	11.5	0.2	400	1.6	2nd He reading 1.6			
MPC-15	04/11/93	2.00	16:10	0.33	2.33	3.36	10.9	0.2	520	0.98	2nd He reading .99			
MPC-24	04/09/93	0.00	08:20	0.00	0.00	0.00	19.9	0.05	240	3.2		Trend of	New	k
MPC-24	04/09/93	0.00	11:58	0.10	0.10	0.14	19.8	0.2	400	2.2	2nd He reading 2.5	O2/Time	x-values	0.00127
MPC-24	04/09/93	0.00	19:35	0.42	0.42	0.60	19.6	0.3	600	1.9	2nd He reading 1.7	20.221213	0	
MPC-24	04/10/93	1.00	09:35	0.00	1.00	1.44	19.2	0.4	920	1.9	2nd He reading 1.7	16.066792	3.28	
MPC-24	04/10/93	1.00	19:40	0.42	1.42	2.04	17.7	0.8	1280	1.2	2nd He reading 1.2			
MPC-24	04/11/93	2.00	09:42	0.00	2.00	2.89	16.3	1.7	1720	1	2nd He reading 1.2			
MPC-24	04/11/93	2.00	16:13	0.28	2.28	3.28	15.9	2.3	2000	0.87	2nd He reading .93			

APPENDIX B
O&M INSTRUCTIONS

APPENDIX B

OPERATION AND MAINTENANCE INSTRUCTIONS

1.0 BLOWER/MOTOR MAINTENANCE

A Gast® regenerative blower, model number R4110N-50, has been installed at Site FT-13. Blower performance curves for model R4110A-2, which are identical to those of R4110N-50, are included in this appendix. The blower and motor are relatively maintenance free. There is no lubrication required because the blower and motor have sealed bearings. If a blower system is in need of repair, please contact Todd Wiedemeier of Engineering-Science, Inc. (ES) in Denver, Colorado at (303) 831-8100.

2.0 FILTER MAINTENANCE

To avoid damage caused by passing solids through the blower, an air filter has been installed inline before the blower. By design, Gast® regenerative blowers are able to ingest small quantities of particles without damage. However, continuous ingestion of solids will damage or imbalance the impellers. The inline air filter will prevent solids from entering the blower and is rated at 99 percent efficiency to 10 microns.

The filter element is a polyester cloth and is cleanable and replaceable. The filter should be checked weekly for the first 2 months of operation. The air filter should be cleaned or replaced when the pressure difference across the filter reaches 15 to 20 inches of water. It will be the responsibility of Kirtland Air Force Base (AFB) personnel to determine the best schedule for filter cleaning and/or replacement depending on the results of the initial observations.

The filter can be checked after turning off the blower system. To remove the filter, loosen the clamps, lift the metal top off of the air filter, and lift the air filter from the metal housing. When replacing the filter, be careful to ensure that the rubber seals remain in place. ES has provided Kirtland AFB with a supply of air filters for the next year of blower operation. Should additional air filters be required, they can be ordered from Solberg Manufacturing, Inc. in Itasca, Illinois. Their phone number is (708) 773-1363. It is recommended that Kirtland AFB keep a spare air filter at each site.

3.0 BLOWER PERFORMANCE MONITORING

To monitor the blower performance, vacuum, pressure, and temperature must be measured. These data should be recorded on the data collection sheets provided. All measurements will be taken at the same time while the system is running.

3.1 Pressure/Vacuum

Open the shed roof and record the pressure and vacuum readings directly from the gauges in inches of water. Pressure readings are necessary to determine design parameters, and to verify that the blower is operating correctly. Vacuum readings are necessary to assure that the filter is clean. Record the measurements on the data collection sheet provided.

3.2 Temperature

Open the shed roof and record the temperature readings directly from the gauges in degrees Fahrenheit (°F). Record the measurements on the data collection sheet provided. Temperature readings are necessary to verify that the blower is operating correctly. The temperature should remain relatively constant with time. Should the temperature rise substantially in a short period of time, a problem may exist within the blower. Ambient air temperature fluctuations will affect the temperature readings but the temperature rise across the blower should not vary by more than 20°F.

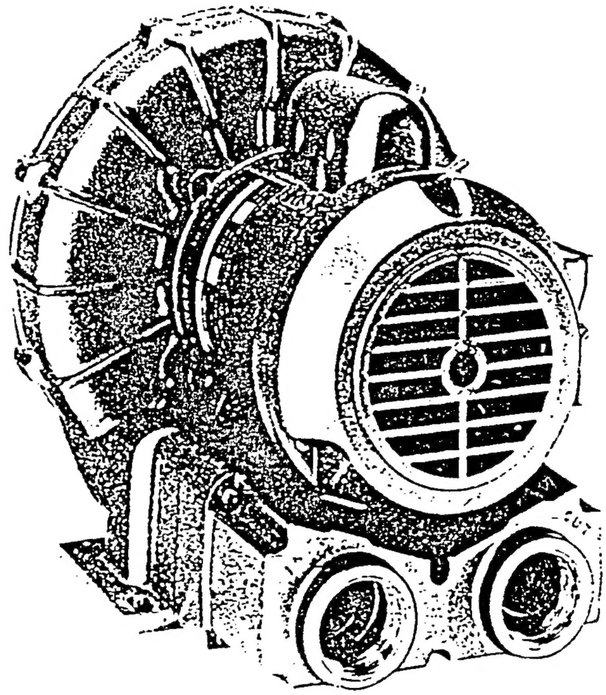
4.0 MONITORING SCHEDULE

The following monitoring schedule is recommended for this system. During the initial months of operation, more frequent monitoring is recommended to ensure that any start up problems are quickly corrected. Data collection sheets have been provided for use by Kirtland AFB personnel during data collection.

Monitoring Item	Monitoring Frequency
Blower vacuum and temperature	Weekly.
Filter change	As required. When vacuum across filter exceeds 15 inches of H_2O.

GAST

R4 Series



MODEL R4110-2

48" H_2O MAX. VAC., 88 CFM OPEN FLOW

PRODUCT FEATURES

- Oilless operation
- TEFC motor mounted
- Can be mounted in any plane
- Rugged construction/low maintenance
- Can be operated blanked-off

COMMON MOTOR OPTIONS

- 115/208-230V, 60 Hz; 110/220-240V, 50 Hz, single phase
- 208-230/460V, 60 Hz; 190-230/380-415V, 50 Hz, three phase
- 575V, 60 Hz, three phase

RECOMMENDED ACCESSORIES

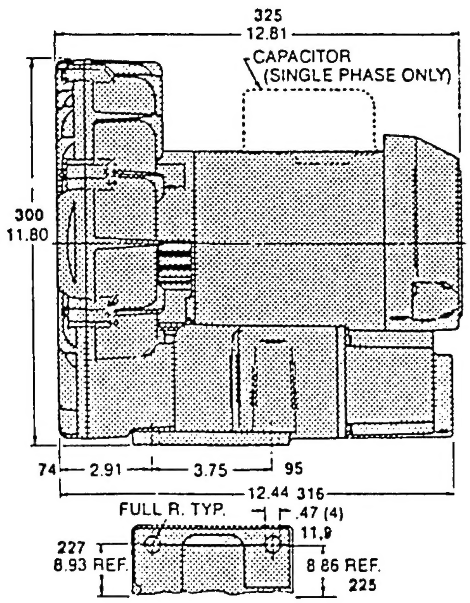
- Vacuum gauge AJ497
- Automotive-type filter AG337
- Muffler AJ121D
- Relief valve AG258

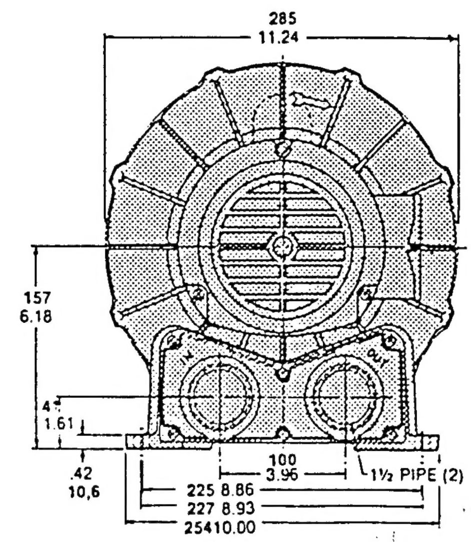
Various brand name motors are used on any model at the discretion of Gast Mfg. Corp.

Important Notice:

Pictorial and dimensional data is subject to change without notice.

Product Dimensions   Metric (mm)   U.S. Imperial (inches)



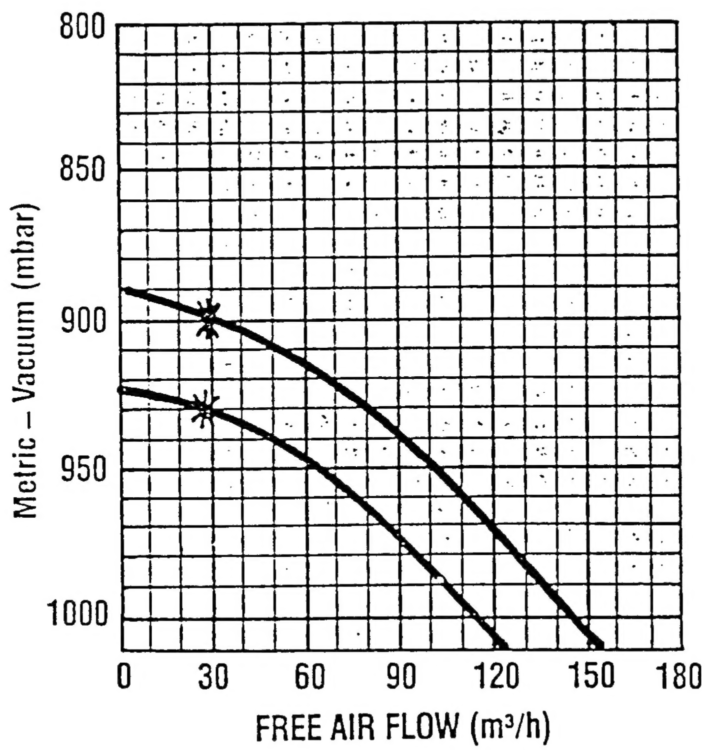


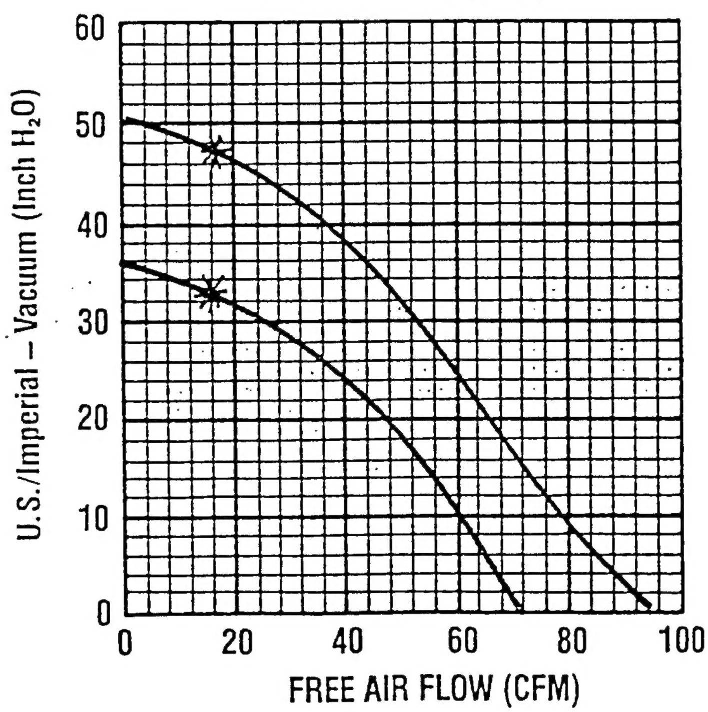
Product Specifications

Model Number	Hz	Motor Specs	HP	RPM	Max Vac		Max Flow		Net Wt.	
					"H_2O	mbar	cfm	m^3h	lbs.	kg
R4110-2	50	110/220-240-50-1	0.6	2850	34	924	72	122	41	18.6
	60	115/208-230-60-1	1.0	3450	48	895	88	150		
R4310A-2	50	190-220/380-415-50-3	0.6	2850	34	924	72	122	41	18,6
	60	208-230/460-3	1.0	3450	48	895	88	150		

Product Performance (Metric U.S. Imperial)

Black line on curve is for 60 cycle performance.
Blue line on curve is for 50 cycle performance.





*Maximum achievable static pressure under continuous operation.

REGENERATIVE BLOWER
INJECTION SYSTEM DATA COLLECTION SHEET

SITE:________

DATE	TIME	INLET VACUUM (IN. WATER)	OUTLET TEMP. (DEGREES F)	OUTLET PRESSURE (IN. WATER)	BLOWER FUNCTIONING UPON ARRIVAL (Y or N)	FILTER CHANGED (Y or N)	COMMENTS	CHECKED BY